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LIFE-CYCLE COST DATABASE DESIGN AND SAMPLE DATA DEVELOPMENT.(U)
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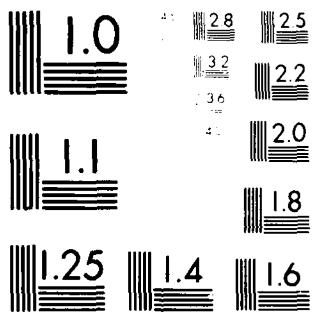

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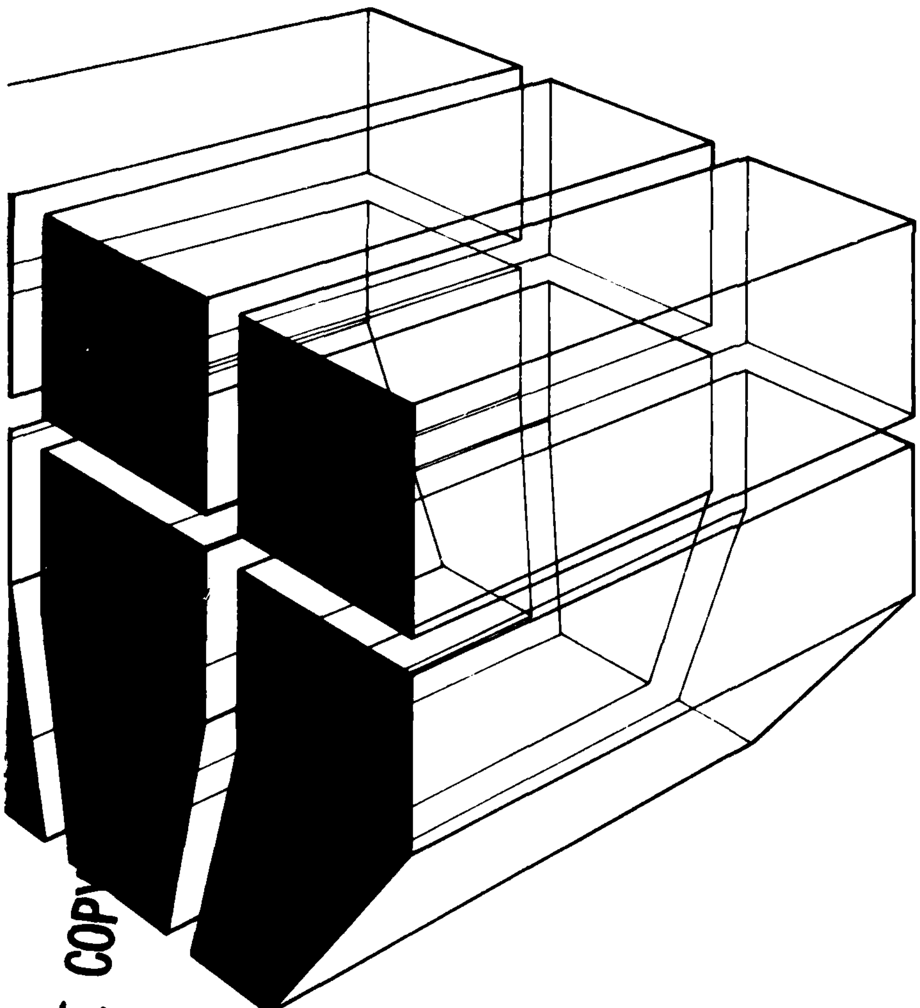
Interim Report P-120
February 1981

AD A097222

LIFE-CYCLE COST DATABASE DESIGN AND SAMPLE DATA DEVELOPMENT



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This report documents the first two phases of a study to design a Life-Cycle Cost (LCC) database that will provide cost-effective procedures for collecting and presenting maintenance and repair (M&R) data for Army facilities. The first two phases of the study were (1) problem definition and prior work analysis, and (2) data collection feasibility evaluation. Installation and District designers/planners require different levels of M&R data than OCE planners to do their work most effectively. Thus, two databases with different levels of detail are required. Collection of data could be done in two

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Block 20 continued.

ways: (1) implementing a one-time data collection program at eight installations to collect M&R information across age groups of buildings and types of construction, or (2) analyzing Integrated Facilities System (IFS) tapes from a sample group of installations. *Because of problems in both of these methods, it was determined that the best means of obtaining data for a database at the present time is by contract, using engineered performance standards taken from Army publications.*

FOREWORD

This research was conducted for the Directorate of Military Progams, Office of the Chief of Engineers (OCE), under RDT&E Program 6.27.31A, Project 4A762731AT41; Task A, "Planning and Design"; Work Unit 033; "Life Cycle Cost Data Base."

The work was performed by the Facilities Systems Division (FS) of the U.S. Army Construction Engineering Research Laboratory (CERL).

Dr. Larry Schindler was the OCE Technical Monitor. Administrative support was provided by Mr. E. A. Lotz, Chief of the Facilities Systems Division.

COL L. J. Circeo is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

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LIFE-CYCLE COST DATABASE DESIGN
AND SAMPLE DATA DEVELOPMENT

1 INTRODUCTION

Background

Life-cycle cost (LCC) analysis is a costing technique used to evaluate alternative construction materials, systems, and designs. The Department of Defense Construction Criteria Manual 4270.1-M[1] requires use of this technique during the design phase of any new military construction project, with documentation required for projects exceeding $300,000. Engineer Technical Letter 1110-3-296[2] provides policy for conducting LCC-based economic studies as part of the design process. Implementation of procedures discussed in the above documents requires consideration of all costs (before, during, and after construction) associated with selection of design materials, systems, subsystems, and components over the life of a facility. These include maintenance, repair, operational, custodial, demolition, salvage, design, and construction costs.

Initial design and construction costs, operational, custodial, demolition, and salvage costs over the life of a facility are generally available or can be computed from the architectural drawings. However, detailed estimates of maintenance and repair (M&R) costs over a facility's life are not readily available. Thus, there is a need for an LCC database that will provide cost-effective procedures for collecting and presenting M&R data for Army facilities. Such a database would reduce the amount of time Army personnel need to spend on LCC data collection and thus substantially reduce the amount of money spent on LCC.

This study consists of three phases: (1) problem definition and prior work analysis, (2) data collection feasibility evaluation, and (3) development and implementation of data collection procedures.

Purpose

The purpose of this phase of the research was to identify LCC data needs of Army personnel and to evaluate the feasibility of obtaining the information necessary for LCC databases from various existing sources.

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[1] Construction Criteria Manual, DOD 4270.1-M (Office of the Assistant Secretary of Defense, Installations and Logistics, 1 October 1972).

[2] Economic Studies, Engineer Technical Letter 1110-3-296 (Office of the Chief of Engineers, 11 October 1978).

Approach

As much information as possible that might be useful for the databases was obtained through a literature search and through contacts with government agencies and private firms. A questionnaire was sent to seven Corps District Offices to obtain the opinions of their personnel on LCC data needs. In addition, a workshop was held to obtain guidance for future work on the databases. Data collection procedures, including the IFS, were examined. Red Book and IFS data were analyzed to see if they could be useful sources of information for the databases. Finally, a method of using Engineered Performance Standards with M&R requirements to develop the databases was investigated. Chapter 3 summarizes work prior to FY79, while Chapter 4 summarizes FY79-80 results. Chapter 5 presents details of using IFS data from two installations and Chapter 6 presents detailed analyses of Red Book data. Chapter 7 discusses use of engineered performance standards and Chapter 8 presents the database design. Conclusions are given in Chapter 9.

Scope

The most difficult aspect of designing the LCC databases is the data collection procedure. The design (format, level of detail, items to include) is trivial compared to the problem of actually collecting reliable data in a cost-effective manner. Thus, most of this report concerns data collection methods.

Mode of Technology Transfer

The information in this report will be disseminated as part of a new Technical Manual.

2 PROBLEM DEFINITION

In FY79, the Army spent $632 million for M&R of buildings (including air-conditioning and heating plants).[3] This is 27 percent of the $2,335 million spent by the Army to operate and maintain all of its facilities. It is obvious that LCC of buildings is a major concern to the Army and that reducing M&R costs for buildings will produce substantial savings.

DOD Construction Criteria Manual 4270.1-M recognizes the problem of reducing ownership costs and requires LCC analyses on all new projects, with documentation required in the project file for projects of $300,000 or more. Engineering Technical Letter 1110-3-296 provides policies on performing LCC economic studies; however, it does not provide detailed procedures, such as equations, and contains no LCC data.

Thus, regulations require LCC analyses, but designers/planners must develop their own estimates of M&R costs. This results in an unnecessarily time-consuming and costly work effort and leads to inconsistencies when similar design evaluations are done by different persons. The designers need a detailed database of M&R costs in order to compute LCC costs for design alternatives and to maintain consistency among several analyses.

Planners at the installation level also need M&R data to justify new construction versus modification of existing facilities. Such a justification requires an LCC analysis; however, the M&R data needed is at a grosser level than that required by the designers.

OCE planners also require M&R cost data for the various types of facilities on a summary level for use in planning and for responding to Congressional queries.

A database must be designed that contains M&R cost information for various building types; this database must meet the needs of (1) OCE planners and (2) designers and planners at the installation and District levels. In fact, two or three different databases may be required to satisfy the needs of these three groups of users. Once the design is formulated, the feasibility of obtaining the data must be addressed.

[3] Facilities Engineering Annual Summary of Operations, Fiscal Year 1979, (Department of the Army, Office of the Chief of Engineers, 1980).

3 SUMMARY OF PRIOR WORK

Much prior work applicable to an LCC database design has been documented in two CERL technical reports.[4] Results of this and other prior work are summarized below:

1. A survey of 51 designers/planners in five Districts determined the type of LCC data needed and the availability of such data. (Results of this survey are discussed with those of a similar survey done in FY79 in Chapter 4.)

2. The U.S. Army Construction Engineering Research Laboratory (CERL) studied the problem of obtaining very detailed M&R data from Facilities Engineers (FEs) at several installations. It was found that FEs did not have records sufficiently complete or detailed to compute LCC. The conclusion was that someone would have to be stationed at the installation to coordinate data collection activities.

In 1975, a coordinator was stationed at Fort Ord, CA, to collect data on selected sample facilities for 1 year. It was then concluded that M&R data can be obtained at the installation level, but not without first modifying the existing FE work management system (DA Pamphlet 420-6)[5] and the Integrated Facilities System (IFS).[6] Three major problems were encountered with the data collection:

a. The work orders were deficient in LCC data.

b. Descriptions on the work orders of tasks performed were often ambiguous.

c. Work performed was not easily correlated to the facility components list.

Items frequently omitted from the work orders were location of work, quantity and cost of materials, and specific work descriptions. Ambiguous descriptions made it difficult to properly allocate labor and equipment costs to specific facility components. Cost data were questionable, since actual material costs were not regularly recorded on the work order forms. This was especially true for service orders (SOs) because they typically used shop stock.

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[4] J. G. Kirby, Life Expectancy of Structures, Preliminary Report A-14/760489 (U.S. Army Construction Engineering Research Laboratory [CERL]), April 1973; E. K. C. Lee, J. G. Kirby, and J. M. Grgas, Information and Retrieval System for Life Expectancy of Facilities, Technical Report P-22/AD#782912 (CERL, May 1974).

[5] Resources Management System, DA Pamphlet 420-6 (Office of the Chief of Engineers, 15 May 1978).

[6] Integrated Facilities System, 18-1-B-AKA (U.S. Army Computer Systems Command, 1978; changes 1 April 1979, 1 February 1979).

An additional problem compounded the difficulties listed above; the person hired and trained to coordinate the work quit after 6 months, so another person had to be hired and trained.

Although this trial data collection effort was not completely successful, such on-site collection is believed to be feasible. A coordinator could be stationed at eight installations (two in each of four geographic regions to determine the effects of climate). Evaluation of such effects is needed to insure validity of inferences drawn from the data. Detailed, highly accurate data could be collected on a sample group of buildings. To compare the effects of age and types of construction would require about 5 years of data. This would be a one-time program and would cost about $1 million. This cost, plus the major problem of varying levels of M&R at different installations, makes this method unacceptable.

3. Contacts with other government agencies and private companies showed that no LCC database existed.

4. The UNIFORMAT method of coding facility components and subcomponents was determined to be appropriate for a highly detailed database.

5. Obtaining data at a level below facility components (roofs, floors, heating system, etc.) would require modification of either the FE manual system or IFS; i.e. obtaining data on various types of floor coverings or roofs would require changing the existing data recording/collection systems. These changes would require more effort from the FE staff and would greatly change the recordkeeping for buildings having multiple types of one component.

4 PRESENT STUDY - APPROACH AND RESULTS

Approach

The (FY79-80) study was set up to design the database and develop sample data, using information from Districts, FEs, and private organizations. This involved performing a literature search and contacting private firms, other government agencies, trade associations, District offices, and FEs.

Results

An exhaustive literature search revealed no available detailed database of M&R costs.

Contacts were made with the following Government agencies and private organizations to determine if any LCC databases exist or are being planned:

American Inst. of Architects
Booz-Allen and Hamilton
Chanute AFB
Cost Systems Engineer, Inc.
Federal Construction Council
General Services Administration
Dept. of Health, Education, and Welfare
National Bureau of Standards
Smith, Hinchman & Grylls
Various Trade Associations (30)

U.S. Air Force (Engrg. & Const. Div.)
U.S. Navy (NAVFAC)
U.S. Postal Service
OCE
Corps of Engineers District Offices - Baltimore, Fort Worth, Mobile, New York Norfolk, Omaha, Sacramento, Savannah
U.S. Army Forts Benning, Bragg, Campbell, Leonard Wood, Knox, Sill

From these contacts, it was ascertained that the only known detailed database is one at Cost Systems Engineer, Inc.; details about this database could not be obtained, but it is known that it is based on data from hotel operators and housing development operators.

It was found that the private sector typically either uses a percentage of initial costs to estimate annual operating and maintenance (O&M) costs or develops required data on a project-by-project basis.

In 1979, a questionnaire was sent to several branches of seven Corps District offices to determine their opinions on LCC data. The following branches responded:

District	Branches Responding
Baltimore	Architectural, Electrical, Mechanical, Structural, Estimating
Kansas City	Architectural, Electrical, Mechanical, Structural, Estimating & Specifications
Mobile	Architectural, Electrical, Mechanical, Structural, Environmental Control, Environmental Site
Norfolk	Architectural, Electrical, Mechanical, Structural, Estimating
Omaha	Architectural, Electrical, Mechanical, Structural, Estimating
Sacramento	Architectural, Electrical, Mechanical, Structural

District	Branches Responding
Savannah	Architectural, Electrical, Mechanical, Structural, Cost Engineering

A similar survey of 51 personnel in five Districts had been done in FY75. A comparison revealed that results of the two surveys were very similar. Appendix A provides a copy of the 1979 questionnaire, and shows the percent responses given for each question. Results of the questionnaire indicated that the respondents prefer data to be:

1. Grouped by installation.

2. Categorized by facility type (BOQs, administration, etc.).

3. Given for type of component, such as LCC of vinyl asbestos tile, nylon carpet, oak strip floor, etc.

4. Given as an average cost ($/SF/yr).

5. Expressed in terms of per-unit cost of materials, installation, maintenance, and equipment rental cost.

In addition, the respondents felt that their current data sources do not have the potential for Corps-wide use. The District personnel believe that cooling systems, heating systems, exterior walls, and lighting fixtures have greatest potential for M&R cost savings, while flooring, cooling systems, roof surfaces, and heating systems are the most expensive M&R items.

A workshop was held in July 1979 with representatives from District offices, installations, other Federal agencies, private industry, universities, and the Office of the Chief of Engineers (OCE). The workshop was held to review progress on the work unit and to provide a consensus on the database design and guidance for future efforts. Appendix B summarizes the results of the workshop. The most important conclusions were:

1. The databases should not be comprehensive for all types of building components and subcomponents.

2. Detailed databases should be designed and developed primarily for building components (a) which require large amounts of Army M&R dollars which are reducible through design, and (b) which are high-quantity or damage-progagating.

3. The databases should not be computerized.

4. IFS data from sample installations and the 5-year MCA plan should be used to determine which components should be studied initially.

5. Detailed data may be obtainable from FE staffs or by use of maintenance standards.

The results described above were used as the basis for FY80 work. Results of the FY80 effort are given in Chapters 5 through 8 of this report, with a summary given below.

Summary

Two distinct databases are needed for Corps of Engineers LCC analyses. A detailed database is required for building components so that designers can expeditiously compute accurate and consistent LCCs for alternative building designs. Planners/programmers need a programming database for various types, ages, and construction types of facilities for justifying new construction and evaluating M&R cost trends.

Detailed Database

Figures 4 through 7 show the database structure for four building components. Data can be collected either from Army installations or by developing preventive maintenance schedules, and expected repair schedules, and using engineered performance standards* (EPS) to determine required labor hours.

Data collected from Army installations might be more reliable because it is based on real Army experience. The major drawback is that installations have different maintenance levels because of amount of funds, FE philosophy, command philosophy, and user differences. Collection of such data would be best accomplished through IFS, since the system is now being used at all major installations. However, IFS files presently do not contain data for M&R done by contract. Also, when a building has several types of a component (e.g., concrete floor finish, wood, and vinyl asbestos tile), costs cannot be assigned to the correct type. The second way of collecting data is to employ someone whose job is to collect all data for a sample of buildings. This would involve checking the accuracy and completeness of all Service Orders, Individual Job Orders, and Standing Operations Orders for the sample buildings. In addition, the buildings would be checked frequently to determine the value of any "self help" performed. An appropriate sample size is 320 and is computed as follows:

$$4 \text{ age groups} \times 8 \text{ facility types} \times 10 \text{ buildings} = 320$$

To estimate time trends, the data would be collected for 5 years to allow replacement of one-third of long-life (15-year) components. It also gives 5 years of data for items requiring yearly M&R. An estimate of the cost is:

$$8 \text{ installations} \times \$14{,}000 \text{ (GS-7 salary)} \times 1.70 \text{ (overhead)} \times 5 \text{ years} = \$952{,}000$$

There are no personnel currently available in FE organizations for this work. OCE would either have to provide an additional personnel space or contract the data collection.

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* Engineered performance standards are given in a series of Technical Bulletins 420-1, 420-2, 420-3, etc. These standards give times required to perform maintenance work. They are based on observation of maintenance craftsmen and use of industrial engineering techniques.

The EPS method outlined below is presently the best way to develop detailed M&R data. For each component:

1. A schedule of preventive maintenance (PM) is determined using the manufacturer's recommendations, the contractor's experience, and other sources.

2. Each PM job is broken into tasks, and the manpower requirements for each task are determined using EPS.

3. The expected failure rate of the component is used to determine frequency of repairs.

4. Each repair job is tasked as in No. 2 above.

5. Material requirements are calculated for each PM or repair job.

6. Yearly total manpower and material requirements are calculated.

The cost for developing data for heating and cooling systems, roofs, floors, electrical systems, exterior walls, windows, and structures is estimated to be $315,000.

Programming Database (PD)

There are two ways to collect data for this database: one is to use IFS if and when contract data is included, and the second is to have data collected at a sample group of installations by a person at each post.

If the collection plan for the detailed database is implemented, the data could be summarized for the PD. If this plan is not implemented, a second, less costly plan could be used. The data collector would go through contracts and collect data for the sample buildings not on IFS. He/she would use IFS to collect much of the data (since component-level detail is not required) and would also check on any "self help" performed. A sample of 480 buildings would be required:

4 age groups x 8 facility types x 3 construction types x 5 buildings = 480

It is estimated that only 1/2 man-year would be required, so the cost would be about $476,000. Since the FE does not have the manpower available to perform this work, the best source of personnel would be a contractor or a retired employee.

Whether such an expenditure is worthwhile depends on the value placed on having M&R cost information for various ages of various types of construction for different facility classifications.

5 IFS DATA ANALYSIS

In FY80, IFS data was analyzed at sample installations to ascertain its potential for generating detailed LCC data and for how effectively it could be used in summary form to determine high-cost M&R building components.

The installations with the best working IFS packages and with personnel most knowledgeable in its use were Fort Sill, OK, and Fort Knox, KY, according to personnel at the Facilities Engineering Support Agency (FESA), Fort Lee, VA.

The IFS was examined to determine the level of detail at which data is available and can be made available.

It was found that the Assets Accounting (AA) module contains detailed building component descriptions for roofing, structure, flooring, heating, and air conditioning; however, it does not contain detailed descriptions of plumbing or electrical components. The AA module also contains cost data for maintenance and repair for each facility. This data is accountable to the facility component (e.g., the roof), but not to the part of the component (e.g., the roof's structure, deck, or surface). A description of the work is also recorded on the historical file, and can often be extracted manually and charged to the appropriate subcomponent in another computer system. However, when a building has two types of roofing, it is not usually possible to assign roofing repair costs to the proper subcomponents.

Two IFS computer tapes were obtained from each post for FY78 and FY79. These contained the Recurring Maintenance and Deficiency (R&D$) Master File (A18AKA) and the Installation Management and Planning File (IM&P) (A09AKA). The R&D$ tape contains the M&R costs for each component for each facility during the current fiscal year and cumulative costs for that component since IFS began. Figure 1 is a page from an R&D$ printout. The IM&P tape contains a detailed description of the facility, including its classification, unit of measure, size, type of construction, current use, utilities available, year built, type walls, floors, roofs, air-conditioning and heating capacities, etc. The General Systems Document, Vol. 5, of the IFS documentation describes the contents of these two tapes in detail.

Programs were written to abstract data from the tapes for further analysis. (For this analysis, only data for buildings was used.) The programs were designed so that any combination of fiscal years for the data, facility classification, year constructed, and type of construction (permanent, temporary, semi-permanent) could be grouped. Then M&R costs could be summarized for each building component. Figure 2 is an example of such a summary.

One shortcoming of the data from the R&D$ file is that it contains only in-house costs. Contract costs (which can be as much as 50 percent of all M&R costs) are not included. Contract files for FY78 and FY79 were examined, and cost data was abstracted and placed into a computer database for joint analysis with the IFS data. There were three major difficulties in abstracting this data: (1) when several components were repaired on the same contract, costs for each were not always given; (2) sometimes, when several

PREPARED INVALID 'R' and 'D' DOLLAR REPORTS - BUILDINGS PCN AKA-006 AE01 A/OF 25 SEP 79
INSTALLATION NAME FORT SILL OK INSTALLATION NO. 40755 RELATION CODE 40755 ARMY LOCATION CODE 40801

FACILITY NO. SUF P00050 FUNCTIONAL GROUP 73000 UM 1 SF UM 1 AMOUNT 1553.0

PART 1 - "D" DOLLARS BY COMPONENT

MONTH & YR.	ROOF	STRUCT	FLOOR COVER	EXTER PAINT	INTER PAINT	HEAT-ING	AIR COND	PLUMB-ING	ELECT-RICAL	EQUIP	TOTAL
0776										39	39
0577		182									182
0677		410									410
0578				452							452
0679								805			805
D $ TOTAL											
THIS YEAR								805			805
CUMULATIVE		592		452				805		39	1888
L $ CUM.											

PART 2 - "R" DOLLARS BY COMPONENT

	ROOF	STRUCT	FLOOR COVER	EXTER PAINT	INTER PAINT	HEAT-ING	AIR COND	PLUMB-ING	ELECT-RICAL	EQUIP	PREV. MAINT	R $ TOTAL
R $ CUM	46	299				43		1118	12	92	188	1798
NO YRS/MOS												5/ 5
NO. EVENT	2	3				3		27	1	2	3	41
UNIT COST	.00	.04	.00	.00	.00	.00	.00	.14	.00	.00	.02	.21
R $ PRIOR												
YEAR								422	12			434
NO. EVENT								14	1			15
UNIT COST												
PRIOR YR.	.34	.00	.00	.00	.00	.00	.00	.27	.01	00	.00	.28
R $ CURR.												
YEAR	22	269				12		134			69	506
NO. EVENT	1	2				1		5			1	10
UNIT COST												
CURR. YR.	.00	.17	.00	.00	.00	.00	.00	09	.00	.00	.04	.33

PAGE 2

Figure 1. Sample page from an R&D$ report.

21405 FORT KNOX KY

REPORT 1

FACILITY CLASS 171
YEAR BUILT ALL
BUILDING TYPE P S T

		A/C	ELEC	EXTR	FLOOR	HEAT	INTR	PLUMB	PM	ROOF	STRC	SYS	TOTAL
FY 1978	$	7712.	36994.	9990.	121.	52147.	41369.	55422.	44235.	2201.	34974.	0.	285165.
	UM												1033823.
	$/UM	.0075	.0358	.0097	.0001	.0504	.0400	.0536	.0097	.0021	0.0000	0.0000	.2758
FY 1979	$	5997.	21118.	12895.	0.	44629.	18728.	10199.	33438.	1027.	24095.	0.	172126.
	UM												1033823.
	$/UM	.0058	.0204	.0125	0.0000	.0432	.0181	.0099	.0125	.0010	0.0000	0.0000	.1665
TOTALS	$	13709.	58112.	22885.	121.	96776.	60097.	65621.	77673.	3228.	59069.	0.	457291.
	UM												2067646.
	$/UM	.0066	.0281	.0111	.0001	.0468	.0291	.0317	.0111	.0016	0.0000	0.0000	.2212

156 BUILDINGS INCLUDED IN THIS REPORT

Figure 2. Sample printout of CERL analysis program.

buildings were repaired on the same contract, costs for each were not always given; and (3) it was sometimes difficult to determine the fiscal year in which the work was completed.

Tables 1 through 4 show the M&R costs for building types that were derived from the IFS tapes and contract files. For comparison purposes, costs are also given which were taken from the "Red Book"* for FY78 and FY79. There is a large difference between Red Book costs and the costs derived from IFS tapes and contract files. There are several reasons for these differences:

1. The derived costs do not include contract M&R costs on installed user equipment.

2. Service contracts were not included in the derived costs.

3. Many of the heating/air-conditioning contracts were not found in the contract files.

4. As much as $900,000 per year of the Red Book costs are pro-rated to the accounts from the K9000 account, which is a type of overhead account for miscellaneous items such as awards, benefits, holidays, severance pay, equipment rental, and some labor. These charges are not made against individual buildings and therefore do not appear in the IFS files.

Table 2 shows the K9000 costs assigned to each building type at Fort Sill. These "residues" are also shown for air-conditioning and heating systems. (Heating and air-conditioning M&R costs are shown as separate items in the Red Book, and are not included in the buildings' M&R costs. (See Chapter 6.)

It is obvious that only local installation employees or someone stationed there for a considerable length of time can find all the contract data and assign costs to individual buildings. This is an expensive process if feasible at all. In addition, the K9000 costs are not assignable to individual buildings. Thus, there is no automated method of obtaining all M&R costs for a building at an installation. The percent derivable costs shown in Tables 1 through 4 can be improved to perhaps 75 percent, but only with considerable expenditure of manpower.

There are many other problems associated with collecting and using data from installations. Some of these are summarized in Appendix C.

* The "Red Book" is the Facilities Engineering Annual Summary of Operations, which contains accounts information submitted by each installation.

Table 1

Fort Sill - FY78 Data

Building Type	Area (x 1000 Sq Ft)	Red Book M&R Costs ($)	IFS (With Contracts) M&R Costs ($)
Training	1734	577078	361532
Maintenance/Prod	1186	384913	161206
RDT&E	11	3119	149
Ammunition Stor	86	3943	932
Other Covered Stor	891	112062	30069
Hospital & Medical	290	211810	113644
Administration	737	197889	262499
Bachelor Housing	4772	2566657	999321
Community Fac	1219	372319	235092
Family Housing	2515	1253675	1037113
Operational	156	40290	17261
Utility Plants	89	49980	27032
Total Costs		5443735	3245895
Heating Systems		2144085	
Air Conditioning		951702	
Red Book Total		8869522	

$$\% \text{ derivable costs} = 100 \times \frac{3245895}{8869522} = 37\%$$

Note: The IFS costs do not include: $500K in prorated overhead-type costs; contract M&R costs on installed user equipment; about $250K in service contracts; and most of the heating/air-conditioning contract costs.

Table 2

Fort Sill - FY79 Data

Building Type	Area (x 1000 Sq Ft)	Red Book M&R Costs ($)	IFS (With Contracts) M&R Costs ($)	Residue*
Training	1734	972534	578819	23634
Maintenance/Prod	1181	574581	116491	20131
RDT&E	10	5097	10151	634
Ammunition Stor	83	42935	35786	1791
Other Covered Stor	900	202122	140529	7480
Hospital & Medical	283	264920	76492	9061
Administration	782	212431	298267	18605
Bachelor Housing	4709	2331520	1636511	114064
Community Fac	1187	403587	561293	25883
Family Housing	2517	1361116	704135	67882
Operational	156	58358	58701	2988
Utility Plants	89	17587	160462	2100
Total Costs		6446788	4378489	294253
Heating		1471819	Heating	285113
Air Conditioning		1439927	Air Conditioning	203152
Red Book Total		9326642	Sub Residue	782518
			Total M&R	5161007

$$\% \text{ derivable costs} = \frac{5161007}{9326642} \times 100 = 55\%$$

Note: The IFS costs do not include contract M&R costs on installed user equipment, service contracts, and many of heating/air-conditioning contract costs.

* From the K9000 account.

Table 3

Fort Knox - FY78 Data

Building Type	Area (x 1000 Sq Ft)	Red Book M&R Costs ($)	IFS (With Contracts) M&R Costs ($)
Training	2391	973524	285165
Maintenance/Prod	1493	1138353	460424
RDT&E	95	68302	46025
Ammunition Stor	62	13283	4012
Other Covered Stor	1157	176866	241392
Hospital & Medical	476	384237	156920
Administration	556	277451	190643
Bachelor Housing	5596	3728121	2621483
Community Fac	1886	1259698	879202
Family Housing	6218	4512042	3009996
Operational	281	84115	106061
Utility Plants	121	230936	98150
Total Costs		12846928	8099473
Heating Systems		689980	
Air Conditioning		856214	
Red Book Total		14393122	

$$\% \text{ derivable costs} = \frac{8099473}{14393122} \times 100 = 56\%$$

Note: The IFS data does not include service contracts, prorated OH costs, most heating/air-conditioning costs, or costs prorated from the K9000 account.

Table 4

Fort Knox - FY79 Data

Building Type	Area (x 1000 Sq Ft)	Red Book M&R Costs ($)	IFS (With Contracts) M&R Costs ($)
Training	2391	719187	172126
Maintenance/Prod	1493	1061235	768336
RDT&E	95	64416	188762
Ammunition Stor	62	10372	1370
Other Covered Stor	1157	338405	120140
Hospital & Medical	476	734478	134448
Administration	551	228152	102604
Bachelor Housing	5596	3867377	2049755
Community Fac	1886	1077550	765995
Family Housing	6218	1852008	3313906
Operational	261	105571	127211
Utility Plants	121	193687	115836
Total Costs		12252438	7860489
Heating Systems		985959	
Air Conditioning		899947	
Red Book Total		14138344	

$$\% \text{ derivable costs} = \frac{7860489}{14138344} = 56\%$$

Note: The IFS data does not include service contracts, prorated OH costs, most heating/air-conditioning costs, or costs prorated from the K9000 account.

6 RED BOOK ANALYSIS

One product of the current work was to be an Interim Programming Database (IPD) showing M&R costs for different building types, preferably by type of construction. Figure 3 shows the database design.

By definition, the data in the database is summary in nature. In designing the IPD, the first approach was to determine the feasibility of obtaining valid, detailed data on a building-by-building basis for a small number of installations. This detailed data could then be "rolled up" to the desired level of summary. The detailed data would also be used to design a detailed database for designers to use. As discussed in Chapter 5, the IFS data analysis effort was not successful. The second approach was to thoroughly analyze data in the Red Book even though it is on a grosser level than desired.

Description of Red Book Data

Each installation annually submits a Facilities Engineering Technical Data Report (DA Form 2788-R) to the Office of the Chief of Engineers (OCE). The data in this report are put into the Red Book. The "K" accounts data are the best available on funds spent for M&R. All M&R funds expended at an installation are given in the Red Book; however, there are some shortcomings in this data. One is that some costs shown in the M&R costs for building types are of an indirect, prorated nature. For example, at Fort Sill in FY79, $114,064 of the $1,357,894 in-house costs for K2700 (Bachelor Housing) were prorated and not directly attributable to work performed on Bachelor Housing. Thus, as listed, the costs per building type are for more than direct labor, normal overheads, material, and equipment. Since they are too large, they can be of use only as upper limits of M&R cost estimates for use in planning. The second major drawback is that heating and air-conditioning (A/C) M&R costs are separated from the type of building in which the A/C systems are actually located. Appendix D, which provides the FY79 data for Fort Sill, shows the heating and A/C M&R costs in accounts K1410-K1443 and K1510-1540, and shows building-type M&R costs in accounts K2110-K2990.

Red Book data for 35 installations were analyzed to determine if statistically significant differences exist, e.g., (1) differences among MACOMS would indicate varying M&R philosophies and/or user characteristics; (2) differences among geographical regions would indicate a need for adjustment factors to account for varying climatic conditions and soil compositions; and (3) differences among fiscal years (FY77-FY79 were analyzed) would show trends over time caused by inflation and/or deteriorating inventory.

Table 5 lists the 35 installations studied in the Red Book analysis, their MACOMs, and their geographical regions. For FY79, the total M&R cost for buildings was $196.0 million, or 63 percent of the total $312 million expended for buildings M&R in the Continental United States (CONUS) in FY79. The heating and A/C M&R costs were $36.0 million, or 64 percent of the CONUS total of $56.0 million.

Building Type	Age Group	Type Construction: One Story Brick	One Story Concrete	One-Story Wood	Multistory Brick	Multistory Concrete	Multistory Wood
Training	1*	**					
	2						
	3						
Maintenance & Prod.	1						
	2						
	3						
Research, Dev. & Test	1						
	2						
	3						
Ammunition Storage	1						
	2						
	3						
Other Covered Storage	1						
	2						
	3						
Hospital/Medical	1						
	2						
	3						
Administration	1						
	2						
	3						
Bachelor Housing	1						
	2						
	3						
Community Facilities	1						
	2						
	3						
Family Housing	1						
	2						
	3						
Operational	1						
	2						
	3						
Utility Plant	1						
	2						
	3						

* Age Group: 1 = 1950-59, 2 = 1960-69, 3 = 1970-79
** $ Cost per Unit Measure

Figure 3. Design of interim programming database.

Table 5

List of Installations Used in Red Book Analysis*

Installations	MACOM	Geographical Region
Fort Bragg	FORSCOM	E
Fort Campbell	FORSCOM	MW
Fort Carson	FORSCOM	W
Fort Devens	FORSCOM	E
Fort Hood	FORSCOM	SW
Fort Sam Houston	FORSCOM	SW
Fort Lewis	FORSCOM	W
Fort Meade	FORSCOM	E
Fort Ord	FORSCOM	W
Fort Polk	FORSCOM	S
Presidio of San Francisco	FORSCOM	W
Fort Riley	FORSCOM	MW
Fort Stewart	FORSCOM	S
Fort Belvoir	TRADOC	E
Fort Benning	TRADOC	S
Fort Bliss	TRADOC	SW
Fort Dix	TRADOC	E
Fort Gordon	TRADOC	S
Fort Jackson	TRADOC	S
Fort Knox	TRADOC	MW
Fort Leavenworth	TRADOC	MW
Fort Lee	TRADOC	E
Fort Rucker	TRADOC	S
Fort Sill	TRADOC	MW
Fort Leonard Wood	TRADOC	MW
Aberdeen Proving Ground	DARCOM	E
Detroit Arsenal	DARCOM	MW
New Cumberland AD	DARCOM	E
Picatinny Arsenal	DARCOM	E
Redstone Arsenal	DARCOM	S
Tooele AD	DARCOM	W
White Sands MR	DARCOM	SW
Walter Reed Hospital	HSC	E
Fort Huachuca	ACC	SW
Fort Monmouth	ACC	E

* E = East, MW = Midwest, S = South, SW = Southwest, W = West.

Results of Data Analysis

Multiple regression analysis was used to determine whether the differences discussed above actually exist. For each building type, the cost per unit area was the variable analyzed. The model used was:

$$\text{Cost/unit area} = f(\text{MACOM, Geographical Region, Fiscal Year}) \quad \text{[Eq 1]}$$

The analysis showed that cost per unit area cannot be predicted accurately with only knowledge of the three variables in the model. The largest multiple correlation coefficient, R, was .68 for community facilities, using all three variables in the model. This means that $R^2 = .46$; i.e., the model explains only 46 percent of the variation among the data for the 35 installations. Table 6 summarizes the analysis results. Note that fiscal years are not statistically significant for any building type. Thus, there is no detectable time trend for any building type. One reason why the model is not a good one is because the data varies so widely. Table 7 gives the cost per unit area of each building type for each year for each installation. Note the variability from year to year for an installation and across installations within a given year. No model is likely to account for such data variation, so the variability must be accepted when using summary information for planning purposes. This means that although an overall M&R cost per unit area can be estimated for all installations, an upper limit would be so high that it would be useless. For example, for training buildings, the FY79 average = $0.393/sq ft. An upper limit (95 percent confidence) would be approximately $0.903/sq ft. (This average is based on total area for training buildings at the 35 installations divided by the total cost for M&R. It is not the average of the 35 costs per unit area.) The FY79 averages shown in Table 8 for each building type in each MACOM and geographical region illustrate the wide differences in unit costs for these two variables.

Interim Programming Database for M&R Costs

Table 9 presents the best estimates of M&R cost per unit area available. Since such costs vary greatly from year to year at a given installation, the estimates should be used only as guidelines. The estimates are a CONUS average, and any particular installation can vary considerably for a specific building type in a given year.

(Because data from the Red Book cannot be broken down into type of construction or year of construction, the six-category and age group breakdown shown in Figure 3 is not possible.)

Table 6

Summary of Multiple Regression Analysis on Red Book Data

Building Type	R	R^2	S_e	Significance
Training	.409	.168	.527	
MACOMS	.300	.090	.540	NS
Geo Reg	.332	.110	.534	NS
Years	.392	.153	.526	NS
Maintenance & Prod	.545	.297	.354	
MACOMS	.420	.176	.376	S
Geo Reg	.328	.108	.391	S
Years	.536	.288	.353	NS
Research, Dev, Test	.534	.286	.389	
MACOMS	.442	.195	.400	NS
Geo Reg	.345	.119	.418	NS
Years	.510	.260	.389	NS
Ammunition Storage	.316	.100	.836	
MACOMS	.260	.068	.836	NS
Geo Reg	.257	.066	.832	NS
Years	.298	.089	.831	NS
Other Covered Stor	.540	.292	.152	
MACOMS	.401	.161	.162	S
Geo Reg	.412	.170	.161	S
Years	.540	.291	.151	NS
Hospital/Medical	.313	.098	.619	
MACOMS	.255	.065	.617	NS
Geo Reg	.178	.032	.628	NS
Years	.307	.094	.614	NS
Administration	.505	.255	.454	
MACOMS	.399	.158	.473	NS
Geo Reg	.364	.132	.480	S
Years	.488	.288	.454	NS

Building Type	R	R^2	S_e	Significance
Bachelor Housing	.390	.153	.667	
MACOMS	.267	.071	.684	NS
Geo Reg	.321	.103	.672	NS
Years	.370	.137	.666	NS
Community Facil	.680	.463	.252	
MACOMS	.361	.130	.315	S
Geo Reg	.611	.373	.267	S
Years	.653	.427	.258	NS
Family Housing	.491	.241	.337	
MACOMS	.323	.104	.358	S
Geo Reg	.444	.197	.339	NS
Years	.490	.241	.333	NS
Operational	.381	.145	1.309	
MACOMS	.235	.056	1.354	NS
Geo Reg	.249	.062	1.342	NS
Years	.370	.137	1.301	NS
Utility Plant	.238	.057	.809	
MACOMS	.210	.044	.797	NS
Geo Reg	.125	.016	.809	NS
Years	.228	.052	.802	NS
Other	.518	.268	3.736	
MACOMS	.493	.243	3.672	NS
Geo Reg	.177	.031	4.153	S
Years	.503	.253	3.708	NS

R = multiple correlation coefficient

S_e = standard error of the regression estimate. Its unit is \$/sq ft. Approximately twice S_e is the upper 95% confidence limit; e.g., for the full model for training buildings, the upper limit = 2 x \$0.527 + .409 = \$1.463.

Significance - "S" means the variable was significant; "NS" means it was not significant; (e.g., for Maintenance & Prod buildings, there is a statistically significant difference among MACOMS and among geographical regions).

Table 7

Maintenace and Repair Costs for Types of Buildings
for 35 Selected Installations for FY77-79

Instal	FY77TRNG	FY78TRNG	FY79TRNG	FY77MAIN	FY78MAIN	FY79MAIN	FY77RDT	FY78RDT	FY79RDT
ABER PR	.269*	.376	.566	.230	.229	.752	.470	.431	.524
FT BELVO	.366	.266	.406	.376	.224	.199	.499	.389	.589
FT BENNI	.183	.333	.213	.478	.236	.114	.013	-0	.004
FT BLISS	.459	.284	.137	.503	.356	.277	.132	.100	.106
FT BRAGG	.291	.143	.304	.290	.270	.302	.013	.049	.064
FT CAMPB	.218	.266	.310	.460	.570	.348	-0	-0	-0
FT CARSO	.381	.202	.285	.366	.317	.484	-0	-0	-0
DETROIT	.369	.358	.718	2.361	2.456	2.369	.645	1.322	.770
FT DEVEN	.434	.478	.407	.434	.840	.466	-0	-0	-0
FT DIX	.402	.618	.449	.420	.327	.515	.592	1.186	.695
FT GORDO	.186	.189	.343	.214	.297	.413	.522	.243	.354
FT HOOD	.688	.396	.770	.445	.138	.170	-0	-0	-0
FT SAM H	.602	.232	.243	.695	.326	.179	.700	.865	.429
FT HUACH	.239	.380	.256	.190	.426	1.075	.219	.651	1.106
FT JACKS	.229	.551	.186	.193	.116	.243	-0	-0	-0
FT KNOX	.355	.407	.301	.491	.762	.711	.656	.719	.678
FT LEAVE	.311	.694	.793	.540	.675	.797	-0	.046	1.624
FT LEE	.405	.383	.755	.266	1.235	.379	.012	.016	.009
FT LEWIS	.117	.141	.164	.164	.202	.372	-0	-0	-0
FT MEADE	.339	.278	.206	.473	.659	.575	.362	.321	.214
FT MONMO	2.515	1.129	.868	.411	.366	.343	.520	.736	1.299
NEW CUMB	5.091	.890	.415	.693	.102	.590	-0	.097	.107
FT ORD	.192	.332	.506	.313	.202	.193	.053	-0	.028
PICATI A	.056	.276	1.074	.293	.310	.520	.385	1.039	.939
FT POLK	.195	.358	.664	.259	.517	.209	-0	-0	-0
PRES OF	.383	.302	.429	.302	.239	.317	1.517	1.484	1.597
REDSTO A	.202	.241	1.053	.452	.275	.651	.176	.291	.157
FT RILEY	.302	.221	.472	.224	.243	.223	-0	-0	-0
FT RUCKE	.223	.215	.227	.230	.220	.280	.122	.135	.318
FT SILL	.587	.324	.561	.348	.325	.487	.081	.284	.510
FT STEWA	.223	.189	.307	.311	.428	1.173	-0	-0	-0
TOOELE A	.084	.088	.192	.430	.295	.659	-0	-0	.557
WALTER R	.227	.127	-0	.886	.629	.586	.617	.835	.882
WHITE SA	.471	.407	.485	.219	.399	.345	.272	.466	.488
FT LEON	.254	.250	.335	.258	.696	1.088	-0	-0	-0
Average **	.343	.330	.393	.381	.367	.441	.440	.562	.643
Total Costs (x$1000)	9192	8872	11011	11094	10806	12734	3866	4868	5572

*$/sqft

**Averages are computed by dividing the total costs by the total area, not by averaging the data in each column.

Note: -0 means there was no maintenance and repair cost or no area given.

Table 7 (Cont'd)

Instal	FY77AMMO	FY78AMMO	FY79AMMO	FY77COVS	FY78COVS	FY79COVS	FY77HOSP	FY78HOSP	FY79HOSP
ABER PR	.122	.158	.224	.145	.125	.355	.591	.347	.552
FT BELVO	.921	.091	.219	.125	.106	-0	.725	.667	.662
FT BENNI	.120	.119	.123	.159	.220	.097	.863	.952	1.864
FT BLISS	.088	.283	.053	.228	.334	.173	.895	1.057	.964
FT BRAGG	.421	.082	.058	.460	.377	.101	.302	.347	.542
FT CAMPB	.023	.028	.009	.570	.161	.161	.679	.607	.486
FT CARSO	.004	.004	.136	.169	.171	.203	.311	.312	.573
DETROIT	-0	-0	-0	.428	.529	.880	2.446	4.067	2.243
FT DEVEN	.000	.005	.007	.149	.165	.116	1.382	1.350	1.309
FT DIX	1.282	.912	.893	.175	.512	.172	.875	1.313	1.599
FT GORDO	.044	.484	.185	.097	.121	.518	.651	.804	.731
FT HOOD	.036	.031	.008	.316	.125	.066	.478	.367	.433
FT SAM H	.007	.004	.567	.168	.259	.528	.388	.605	.629
FT HUACH	.014	.153	1.528	.105	.312	.249	.570	.597	.500
FT JACKS	-0	-0	-0	.066	.118	.080	.686	1.261	.907
FT KNOX	.274	.214	.167	.342	.153	.292	.811	.807	1.543
FT LEAVE	7.634	2.144	.216	.162	.095	.058	.672	.439	.599
FT LEE	.043	.021	.052	.535	.414	.108	.343	.346	.322
FT LEWIS	.025	.605	.082	.086	.107	.064	1.029	1.423	2.868
FT MEADE	.135	.319	.075	.156	.331	.255	2.778	1.465	.879
FT MONMO	.076	-0	.040	.290	.232	.184	1.422	1.077	.729
NEW CUMB	.114	.089	.339	.507	.255	.419	1.362	1.145	1.773
FT ORD	.016	.078	.031	.128	.129	.100	.632	.593	.292
PICATI A	.234	.487	1.283	.231	.495	.714	-0	-0	-0
FT POLK	.492	.153	.120	.379	.129	.122	.522	.490	.417
PRES OF	.059	.357	.027	.195	.193	.261	.919	.814	.890
REDSTO A	.020	.041	.032	.028	.036	.265	.403	.671	.397
FT RILEY	.109	.027	.084	.379	.436	.077	.475	.235	.434
FT RUCKE	.121	.112	.149	.098	.052	.075	.343	.228	.621
FT SILL	.129	.046	.517	.329	.141	.225	.633	.730	.936
FT STEWA	.128	.056	.131	.160	.289	.284	.925	1.888	.529
TOOELE A	.014	.045	.027	.048	.117	.197	.408	.675	1.287
WALTER R	-0	-0	-0	.644	.791	.365	.960	.625	.651
WHITE SA	.354	.039	.138	.088	.067	.082	.422	.463	.312
FT LEON	.489	.106	.020	.066	.252	.193	.819	1.857	.592
Average	.038	.062	.086	.216	.197	.235	.710	.764	.837
Total Costs (x$1000)	438	752	792	8106	7517	8080	9947	11933	13000

Table 7 (Cont'd)

Instal	FY77ADMN	FY78ADMN	FY79ADMN	FY77BACH	FY78BACH	FY79BACH	FY77COMM	FY78COMM	FY79COMM
ABER PR	.327	.446	.620	.731	.776	.715	.549	.659	1.059
FT BELVO	.689	.621	.859	.435	.383	.595	.607	.605	.922
FT BENNI	.458	1.174	.559	.551	.458	.762	.385	.383	.245
FT BLISS	.370	.332	.221	.762	.455	.368	.446	.484	.904
FT BRAGG	.575	.335	.371	.557	.393	.320	.534	.215	.335
FT CAMPB	.339	.481	.379	.512	.453	.450	.387	.579	.491
FT CARSO	.371	.348	.495	.516	.351	.493	.358	.342	.564
DETROIT	1.549	2.242	2.044	.674	1.055	.885	.791	1.193	1.595
FT DEVEN	.297	.345	.260	.596	.993	.777	.565	.769	.868
FT DIX	.855	.390	.458	.839	.831	.771	.288	.384	.419
FT GORDO	.325	.309	.397	.536	.487	.723	.409	.307	.340
FT HOOD	.445	.144	.240	.439	.373	.462	.364	.267	.436
FT SAM H	.540	.429	.307	.453	.388	.354	.672	.531	.661
FT HUACH	.285	.407	.345	.352	.538	.318	.456	.456	.473
FT JACKS	.425	1.489	.755	.455	.419	.561	.241	.225	.131
FT KNOX	.903	.499	.414	.675	.666	.691	.494	.668	.571
FT LEAVE	1.627	3.202	2.405	2.117	1.073	1.351	.898	.679	.574
FT LEE	.347	.424	.282	.505	.544	.304	.407	1.130	1.157
FT LEWIS	.143	.269	.284	.258	.393	.416	.200	.359	.213
FT MEADE	.471	.849	1.242	.337	.340	.971	.561	.800	.607
FT MONMO	.380	.925	.935	.902	1.239	.943	.498	.322	.308
NEW CUMB	.747	.683	.545	.430	.389	.977	.980	.884	.717
FT ORD	.250	.384	.225	.275	.180	.288	.224	.359	.222
PICATI A	.776	.978	1.334	.957	1.047	6.899	.544	.791	1.106
FT POLK	.499	.685	.366	1.782	.621	.676	.353	.460	.446
PRES OF	.438	.403	.597	.351	.355	.553	.497	.432	.541
REDSTO A	.461	.603	1.820	1.323	.844	.982	.822	1.135	1.216
FT RILEY	.120	.119	.453	.387	.441	.443	.287	.224	.210
FT RUCKE	.424	.182	.489	.239	.702	.841	.304	.450	.317
FT SILL	.276	.269	.272	.378	.538	.495	.396	.305	.340
FT STEWA	.450	.510	.874	.298	.388	.431	.431	.329	.662
TOOELE A	.519	.483	.662	.609	.908	.491	.315	.551	.439
WALTER R	.412	.561	.181	.513	.358	.303	.421	.333	.180
WHITE SA	.405	.271	.318	.339	.415	.288	.645	1.013	2.305
FT LEON	.313	.636	.473	.618	.476	.381	.205	.293	.257
Average	.468	.583	.632	.543	.494	.536	.422	.454	.497
Total Costs (x$1000)	11657	14120	15762	49788	47613	53326	12997	14212	15841

Table 7 (Cont'd)

Instal	FY77FH	FY78FH	FY79FH	FY77OPER	FY78OPER	FY79OPER	FY77UTIL	FY78UTIL	FY79UTIL
ABER PR	.559	.815	.502	.163	.203	.302	.532	.553	.841
FT BELVO	.300	.319	.289	1.331	1.279	.482	.446	.381	.323
FT BENNI	.349	.363	.350	.204	.760	.198	2.711	.147	.240
FT BLISS	.252	.556	.248	.399	.300	.291	.593	1.157	.711
FT BRAGG	.547	.530	.574	.215	.076	.367	.505	1.058	.452
FT CAMPB	.461	.442	.696	.339	.416	.405	.422	.759	.488
FT CARSO	.492	.377	.501	.219	.133	.157	.835	.148	.323
DETROIT	.295	-0	.051	4.754	7.438	4.950	-0	-0	-0
FT DEVEN	.598	.519	.526	.255	.166	.165	.156	.255	.326
FT DIX	.387	.770	.274	.069	.064	.064	.174	.242	.615
FT GORDO	.337	.380	.348	.324	.253	.453	.384	.437	.833
FT HOOD	.191	.256	.333	.311	.135	.202	.383	.211	.283
FT SAM H	.590	.572	.512	.525	.408	.474	.451	1.110	.596
FT HUACH	.652	.480	.841	.404	.973	.219	1.369	.951	.190
FT JACKS	.287	.540	.396	.382	.562	.461	.104	.054	.177
FT KNOX	.302	.726	.298	.240	.322	.404	.491	1.909	1.601
FT LEAVE	.528	.534	.599	.328	.280	.244	1.090	.575	3.517
FT LEE	.480	.403	.519	.265	.242	.173	.590	.277	.299
FT LEWIS	.936	.505	.975	.197	.217	.281	.233	.692	1.151
FT MEADE	.315	.995	.339	.407	.542	.670	.701	.445	.868
FT MONMO	.427	.226	.490	.125	.545	.240	.403	.724	.237
NEW CUMB	.302	1.376	1.383	.482	.431	.362	.877	1.841	4.719
FT ORD	.191	.477	.460	.268	.329	.400	.247	2.111	.336
PICATI A	2.714	.937	1.370	.075	.181	.938	.107	.117	.121
FT POLK	.298	.163	.128	.162	.158	10.055	.132	1.777	.384
PRES OF	.390	.667	.669	.175	.209	.370	.987	.306	.795
REDSTO A	.338	.489	.772	.699	.579	.555	.222	.243	1.075
FT RILEY	.228	.357	.271	.072	.159	.070	.419	.195	.722
FT RUCKE	.581	.362	.476	.743	.195	.132	.973	.355	.503
FT SILL	.364	.498	.541	.421	.257	.374	.174	.549	.198
FT STEWA	.484	.433	.562	.327	.205	.154	3.517	1.615	1.582
TOOELE A	.595	.446	.769	.479	.391	.775	.511	.348	.847
WALTER R	2.232	.721	.623	-0	-0	-0	-0	.136	.448
WHITE SA	.667	.743	.272	.612	.404	.257	1.085	.333	.393
FT LEON	.752	.757	1.006	.009	.126	.108	1.072	3.078	1.473
Average	.434	.507	.492	.239	.278	.302	.649	.671	.762
Total Costs (x$1000)	45465	53216	53717	2636	2395	2499	1943	1970	2225

Table 7 (Cont'd)

Instal	FY77OTHR	FY78OTHR	FY79OTHR
ABER PR	1.138	.580	-0
FT BELVO	1.939	1.656	3.435
FT BENNI	1.221	.319	1.955
FT BLISS	-0	.257	.069
FT BRAGG	.409	.170	.308
FT CAMPB	-0	-0	-0
FT CARSO	1.521	1.295	.067
DETROIT	-0	-0	-0
FT DEVEN	-0	3.191	4.324
FT DIX	6.142	3.741	4.471
FT GORDO	.828	.522	.350
FT HOOD	-0	-0	-0
FT SAM H	1.274	.599	.641
FT HUACH	1.134	2.246	.156
FT JACKS	-0	-0	-0
FT KNOX	-0	-0	-0
FT LEAVE	-0	14.292	16.743
FT LEE	.014	.020	.028
FT LEWIS	.932	2.542	16.213
FT MEADE	.451	.325	1.909
FT MONMO	-0	-0	-0
NEW CUMB	-0	-0	-0
FT ORD	.101	4.914	5.528
PICATI A	-0	-0	-0
FT POLK	.002	-0	.005
PRES OF	18.873	5.556	6.281
REDSTO A	1.048	-0	3.254
FT RILEY	-0	.166	1.446
FT RUCKE	.134	.151	.190
FT SILL	6.820	.793	.129
FT STEWA	.024	.139	.158
TOOELE A	1.397	2.136	3.905
WALTER R	-0	.012	.012
WHITE SA	-0	-0	-0
FT LEON	-0	-0	-0
Average	.134	.404	.489
Total Costs (x$1000)	617	1142	1388

Table 8

Average Dollar Cost Per Unit Area for FY79 by Building Type for Each MACOM and Each Geographical Region

Building Type	MACOM					Geographical Region				
	FORSCOM	TRADOC	DARCOM	ACC	HSC	E	S	MW	SW	W
Training	.390(13)	.392(12)	.643(7)	.562(2)	--	.545(10)	.427(7)	.498(7)	.376(5)	.315(5)
Maintenance & Production	.385(13)	.459(12)	.841(7)	.709(2)	.586(1)	.475(111)	.440(7)	.860(7)	.409(15)	.405(5)
Research, Dev & Test	.466(5)	.489(10)	.506(7)	1.202(2)	.882(1)	.523(10)	.208(14)	.895(4)	.532(4)	.727(3)
Ammunition Storage	.103(13)	.236(11)	.340(6)	.784(2)	--	.319(10)	.123(6)	.169(6)	.459(5)	.060(5)
Other Covered Storage	.180(13)	.181(11)	.416(7)	.216(2)	.365(1)	.279(10)	.206(7)	.269(7)	.220(5)	.165(5)
Hospital & Medical	.791(13)	.945(12)	1.094(6)	.614(3)	.651(1)	.902(10)	.781(7)	.976(7)	.567(5)	1.182(5)
Administration	.469(13)	.632(12)	1.078(7)	.640(2)	.181(1)	.662(11)	.752(7)	1.920(7)	.286(6)	.452(5)
Bachelor Housing	.481(13)	.515(12)	1.205(7)	.390(2)	.180(1)	.698(11)	.480(7)	.577(7)	.956(5)	.396(5)
Community	.510(13)	.654(12)	1.605(7)	.631(2)	.303(1)	1.234(11)	.711(6)	.671(7)	.358(5)	.448(5)
Family Housing	.504(13)	.445(12)	.731(7)	.666(2)	.623(1)	.626(11)	.433(7)	.496(7)	.441(5)	.675(5)
Operational	1.059(13)	.282(12)	1.163(7)	.229(2)	--	.376(11)	1.715(7)	1.937(7)	.289(5)	.396(5)
Utility Plant	.639(13)	.874(12)	1.333(6)	.213(2)	.448(1)	.840(11)	.685(7)	1.333(6)	.434(5)	.690(5)
Other	3.353(11)	3.401(9)	3.579(2)	.156(1)	.012(1)	2.070(7)	.985(6)	6.106(3)	.289(3)	6.399(5)

Note: The number in parentheses is the number of installations which had M&R costs and upon which the average is based.

Table 9

Estimated M&R Cost Per Unit Area

Building Type	M&R Costs ($/sq ft)
Training	.39
Maintenance & Prod	.44
Research, Dev & Test	.64
Ammunition Storage	.09
Other Covered Storage	.24
Hospital & Medical	.84
Administration	.63
Bachelor Housing	.54
Community Facilities	.50
Family Housing	.49
Operational	.30
Utility Plant	.76
Other	.49

Refinement to IPD

Table 10 shows the heating and A/C costs (accounts K1410-K1443 and K1510-1540) and the other building M&R costs (K2100-2990) for each installation. The table shows the percentage of the other costs that the heating and A/C costs represent. Many of the heating and A/C costs are more than 10 percent of all the other M&R costs and should be included in Table 9. If these data are to be useful to OCE, a method of prorating these heating and A/C M&R costs to building types must be devised.

Table 10

Heating and Air-Conditioning (HAC) Costs at the 35 Installations

INSTALLATION	(1) AIR CONDITIONING	(2) HEATING	(3) OTHER	(((1)+(2))/(3)) X 100%
ABERDEEN PROVING GROUND	1160854	1791934	6789740	30.3
FT. BELVOIR	317901	867953	4143497	22.3
FT. BENNING	677323	630523	9554359	12.0
FT. BLISS	335293	620152	5842755	14.1
FT. BRAGG	361678	691874	8780294	10.7
FT. CAMPBELL	165084	1150556	8349546	13.6
FT. CARSON	38369	453435	5150154	8.7
DETROIT ARSENAL	129935	0	1991056	6.1
FT. DEVENS	71984	823695	5672292	13.6
FT. DIX	170695	368547	6259756	7.9
FT. GORDON	625144	658723	4977944	20.5
FT. HOOD	1021124	754958	8306927	17.6
FT. SAM HOUSTON	723744	465033	4597211	20.5
FT. HUACHUCA	73015	87134	4389675	3.5
FT. JACKSON	205529	446140	4426301	12.8
FT. KNOX	899947	1021433	10252438	15.8
FT. LEAVENWORTH	189213	377063	5658028	9.1
FT. LEE	194734	632729	3578394	18.8
FT. LEWIS	37597	276872	12144080	2.5
FT. MEADE	172984	400007	6519472	8.1
FT. MONMOUTH	308125	349854	4286010	13.3
NEW CUMBERLAND AD	28695	71513	2778038	3.5
FT. ORD	32143	340272	6043823	5.8
PICATINNY ARSENAL	5061	420983	3728634	10.3
FT. POLK	389119	153707	4351797	11.1
PRESIDIO OF SAN FRANCISCO	133121	370607	4763233	9.6
REDSTONE ARSENAL	1132979	598704	6860348	20.2
FT. RILEY	234324	526707	4893063	13.5
FT. RUCKER	637089	330607	3890476	19.9
FT. SILL	1439927	1471819	6458387	31.1
FT. STEWART	1130012	1243743	6359211	27.2
TOOELE AD	48194	277869	1956882	14.3
WALTER REED AMC	688698	2058073	3011144	47.7
WHITE SANDS MISSILE RANGE	344071	503226	1985662	29.9
FT. LEONARD WOOD	269851	339575	7224639	7.8

7 ENGINEERED PERFORMANCE STANDARDS

The latest approach being pursued for development of the detailed database is the development of M&R requirements through application of experience, engineering knowledge, and manufacturers' recommendations. The three highest cost M&R building components -- heating, cooling, and flooring -- were selected by the following process. Data collected from the two surveys of District offices were combined and then compared to the IFS data collected at Forts Knox and Sill. The building components were ranked as shown in Table 11 and an overall ranking developed. In FY80-81, contracts will be awarded to develop M&R data for a medium-sized heating system, several sizes of air-conditioning systems, and floor surfaces. This data will indicate the maintenance (including preventive) and repair tasks (normal/emergency repair) required on the system for each year of the building's life (25 years). The contractor will use experience, engineering judgment, manufacturer's data, other relevant available data, and Army manuals, bulletins, etc., to determine how frequently preventive maintenance and other repair actions occur. Both the manhours per type of craftsman and the materials required will be determined, the former by using applicable Army publications on engineered performance standards. The result will be a database of expected M&R costs for the building component and its subcomponents over a 25-year period in terms of manhours and quantities of materials required. The data will be in manhours and quantities of materials/supplies and therefore will not be affected by inflation, since cost calculations will be made later by the database user.

Table 11

Ranking of Building Components

Ranking of Components By Potential LCC Savings, Surveys 1 & 2 Combined	Ranking of High Cost M&R Component Surveys 1 & 2 Combined	IFS & Contract Data, FY76-79 Forts Knox & Sill	Overall
1 Cooling	1 Flooring	1 Heating	1 Heating
2 Heating	2 Cooling	2 Structure	2 Cooling
3 Exterior Walls	3 Roof Surface	3 Plumbing	3 Flooring
4 Lighting Fixtures	4 Heating	4 Interior Paint	4 Electrical
5 Air Handling	5 Windows & Glass	5 Floors	5 Structure
6 Windows & Glass	6 Lighting Fixtures	6 Electrical	
7 Flooring	7 Exterior Walls	7 Cooling	
8 Steam-Water System	8 Interior Partitions	8 Roofs	
9 Roof Structure	9 Air Handling	9 Exterior Paint	
	10 Gutters & Downspouts		

A contract for developing heating system M&R costs for an administration-type building was awarded in September 1980. Two others -- one for air-conditioning systems and one for floor cover -- will be awarded in early FY81.

8 DATABASE DESIGN

The design of the detailed database is straightforward, since it is not possible to obtain/develop highly detailed data. The database needs only enough detail to differentiate among building component alternatives. For example, for flooring, data are needed for alternatives such as vinyl asbestos tile, sheet vinyl, oak strip, etc. Figures 4 through 7 give the design for floor covering, heating/cooling generation, and heating/cooling distribution. These databases will be used by District office and installation designers to compute M&R costs for the various alternative combinations for these three components. The final database will not encompass all 10 building components, but rather only those for which LCC is large enough to warrant inclusion.

This database will meet the primary objective of the LCC Database Design work unit. However, it will not provide all the data needed by installation and OCE planners. They require design LCC data for new construction and LCC data for existing facilities. Ideally, such data would enable the designer to make a statement such as, "a brick, multi-story BOQ built in 1950-1960 costs x dollars per square foot to maintain." The design of this planning database is shown in Figure 3.

Building Type	Component Alternative		Use Level: Average Manhours/Sq Ft	Use Level: Average Materials/Sq Ft	Use Level: Severe Manhours/Sq Ft	Use Level: Severe Materials/Sq Ft
*	01	TILE AND TERRAZZO	**	***		
	0101	Ceramic Tile				
	0102	Quarry Tile				
	0103	Terrazzo Finish				
	0104	Precast Terrazzo				
	02	WOOD FLOORING				
	0201	Wood Strip				
	0202	Hardwood Parquet				
	0203	Other				
	03	RESILIENT				
	0301	Asphalt Tile				
	0302	Vinyl Tile				
	0303	Vinyl Asbestos Tile				
	0304	Linoleum Sheet				
	0305	Vinyl Sheet				
	0306	Nylon Carpet				
	0307	Wool Carpet				
	0308	Other				
	04	MASONRY				
	0401	Concrete				
	0402	Brick				

* A table will be developed for each building type:

510 - Hospitals
540 - Dental Clinics
550 - Dispensaries
610 - Administrative Buildings
710 - Family Housing
721 - EM Barracks
722 - Bachelor Housing - Mess Facilities
723 - Bachelor Housing - Detached Facilities
723 - BOQs
740 - Community Facilities

** Number of manhours per square foot to maintain and repair the flooring surface each year, given in a range of values. Example: .025-.075 manhours/sq ft.

*** Number of square feet of surface needing replacement per 100 sq ft of flooring surface per year, given in a range of values.

Figure 4. Database for floor coverings.

Building Type	Component Alternative	Size: Less than 750K BTU/HR Manhours	Material	750K-3.0 Million BTU/HR Manhours	Material	Over 3.0 Million BTU/HR Manhours	Material
*	01 FURNACES						
	0101 Gas Fired						
	0102 Oil Fired						
	0103 Coal Fired						
	0104 Electric						
	02 STEAM BOILERS						
	0201 High Pressure-Gas Fired						
	0202 High Pressure-Oil Fired						
	0203 High Pressure-Coal Fired						
	0204 Low Pressure-Gas Fired						
	0205 Low Pressure-Oil Fired						
	0206 Low Pressure-Coal Fired						
	03 HOT WATER BOILERS						
	0301 Gas Fired						
	0302 Oil Fired						
	0303 Coal Fired						
	0304 Electric						
	04 AUXILIARY EQUIPMENT						
	0401 Burners and Stokers						
	0402 Tanks and Tank Heaters						
	0403 Pumps and Deaerators						
	0404 Heat Exchange/Recovery						
	0405 Boiler Breaching and Draft Control						
	0406 Boiler Water Treatment						

* A table will be developed for each building type:

510 - Hospitals	721 - EM Barracks
540 - Dental Clinics	722 - Bachelor Housing - Mess Facilities
550 - Dispensaries	723 - Bachelor Housing - Detached Facilities
610 - Administrative Buildings	723 - BOQs
710 - Family Housing	740 - Community Facilities

Figure 5. Database for heat generation systems.

Building Type	Component Alternative	Manhours Per No. Units or Lin. Ft.	Material Per No. Units or Lin. Ft.
*	01 AIR DISTRIBUTION		
	0101 Fans		
	0102 Motors and Drives		
	0103 Plenums and Casings		
	0104 Coil Sections		
	0105 Ductwork		
	0106 Duct Accessories		
	0107 Mixing Boxes; Pressure, Reheat		
	0108 Filters		
	0109 Humidity Control		
	0110 Heat Recovery Equipment		
	0111 Anti-Vibration Equipment		
	02 EXHAUST VENTILATION		
	0201 Air Exhausters		
	0202 Ventilators		
	0203 Air Make-up Fan		
	0204 Air Make-up Motor and Drive		
	0205 Air Make-up Plenums and Casings		
	0206 Air Make-up Filter Section		
	0207 Air Make-up Motorized Damper		
	0208 Air Make-up Heating Section		
	0209 Ductwork		
	03 STEAM DISTRIBUTION		
	0301 Pipe and Fittings		
	0302 Valves		
	04 WATER DISTRIBUTION		
	0401 Pipe and Fittings		
	0402 Valves		
	0403 Expansion Joints and Specialties		
	05 TERMINAL UNITS		
	0501 Baseboard Heating Unit		
	0502 Convector Heating Unit		
	0503 Induction Unit		
	0504 Enclosures and Cabinets		
	0505 Fan Coil Units		
	0506 Radiators		
	0507 Duct on Unit Mounted Coils		
	0508 Finned Tube Elements		
	0509 Radiant Water Heating System		
	0510 Unit Heater		
	0511 Grills		
	0512 Registers		
	0513 Diffusers		
	06 PACKAGED UNITS		
	0601 Space Heaters		
	0602 Heat Pumps		
	0603 Dehumidifiers		
	07 CONTROLS		
	0701 Thermostats		
	0702 Control Valves		
	0703 Relays		

* A table will be developed for each building type:

510 - Hospitals
540 - Dental Clinics
550 - Dispensaries
610 - Administrative Buildings
710 - Family Housing
721 - EM Barracks
722 - Bachelor Housing - Mess Facilities
723 - Bachelor Housing - Detached Facilities
723 - BOQs
740 - Community Facilities

Figure 6. Database for heating/cooling distribution systems.

Building Type	Component Alternative		Size: Less 5 Tons	5-25 Tons	26-100 Tons	100-300	Over 300 Tons
			Manhours	Matl's	Manhours	Matl's	Manhours Matl's
*	01	CHILLED WATER SYSTEM					
	0101	Chilling Units					
	0102	Positive Displacement Compressor					
	0103	Centrifugal Compressor					
	0104	Absorption Compressor					
	0105	Chilling Towers					
	02	CONDENSER WATER CIRCULATION					
	0201	Pipes and Fittings					
	0202	Valves					
	0203	Strainers					
	0204	Flexible Connectors					
	0205	Pipe Hangers and Supports					
	0206	Pumps					
	0207	Water Treatment					
	03	CHILLED WATER CIRCULATION					
	0301	Pipes and Fittings					
	0302	Valves					
	0303	Strainers					
	0304	Flexible Connectors					
	0305	Pipe Hangers and Supports					
	0306	Pumps					
	0307	Water Treatment					
	04	DIRECT EXPANSION SYSTEMS					
	0401	Compressor Unit					
	0402	Evaporator Unit					
	05	REFRIGERANT CIRCULATION SYSTEM					
	0501	Pipes and Fittings					
	0502	Valves					
	0503	Strainers - Driers					
	0504	Flexible Connectors					
	0505	Pipe Hangers and Supports					
	0506	Pumps					
	0507	Water Treatment					

* A table will be developed for each building type:

510 - Hospitals
540 - Dental Clinics
550 - Dispensaries
610 - Administrative Buildings
710 - Family Housing
721 - EM Barracks
722 - Bachelor Housing - Mess Facilities
723 - Bachelor Housing - Detached Facilities
723 - BOQs
740 - Community Facilities

Figure 7. Database for cooling generation systems.

9 CONCLUSIONS

The LCC data needs of District designers were identified and data bases for three high-cost components were structured.

The detailed database for evaluating alternative construction materials, systems, and designs will be noncomputerized, since it is not large enough to require automation.

The best method to obtain data is by contract, using engineered performance standards taken from Army publications. Collection of data through IFS is not yet feasible.

Red Book data cannot be used to develop costs per unit measure for various building types because (1) heating and air-conditioning costs are separated from the building types, and (2) the prorating of some costs to the building types results in questionable accuracy of the data. Red Book data can only give approximate overall M&R costs for a building type, since all ages and types of construction are included in the overall figures.

A five-year data collection effort for sample buildings at selected installations would produce data for a programming database. This would require an on-site employee at each installation.

APPENDIX A

DISTRICT OFFICE SURVEY QUESTIONNAIRE

DISTRICT LIFE CYCLE COST (LCC) QUESTIONNAIRE

PART I - DATA TYPE AND FORMAT

An effective data collection, storage, and retrieval system to support LCC analysis can only be developed if CE district data needs are identified. This portion of the questionnaire is designed to identify the desired LCC data type and format.

A. Cost Breakdown

1. Which of the following types of cost data do you feel would be most useful (circle letter)?

34% a. Total cost expressed on a per unit basis ($/SF of alternate).

66% b. Cost expressed in terms of the per-unit cost of materials, per-unit cost of installation, per-unit cost of maintenance, and the equipment rental cost, normalized to a per-unit basis.

Comments:____

2. What would be the best way of presenting the cost figures (circle letters)?

45% a. Average: example: cost = $.08/SF/yr

30% b. Range of values: example: cost = $.02 - .08/SF/yr

24% c. Average with confidence interval:

Example: Cost = $.05/SF/yr ± .03 at 95% confidence

(95% of the time the true maintenance cost will be within the interval .03 and .08 $/SF.)

Comments:____

B. Location.

1. Would it be desirable to have data available by geographic location?
   Yes *97%* No *3%*

2. If yes, specify grouping (circle choice).

61% a. by installation

32% b. by district

6% c. by division

Comments:____

C. Facility Type.

Would it be desirable to have data available by facility type (BOQ's, administration, family housing, etc.)
Yes *88%* No *12%*

Comments:____

D. Alternate.

Which level of detail do you feel would be most useful to you in performing life cycle costing (circle number)?

22% 1. Least specific detail which describes the alternate. Example: life cycle cost of flooring type, such as tile floor, carpet, wood floor, etc.

69% 2. Description of type of alternate. Example: life cycle cost of vinyl asbestos tile, nylon carpet, oak strip floor.

9% 3. Description of manufacturer's data for alternate. Example: life cycle cost of Footstrong "Solarina," no-wax asbestos tile, sunburst pattern, yellow.

Comments:____

PART II - CURRENT DATA SOURCES

The identification and estimated occurrence of currently used LCC data sources will be surveyed with the following questions. A single source of LCC data references will be created by this portion of the questionnaire.

List of Building Categories

1. Foundations and footings
2. Structural system
3. Exterior walls
4. Roof structure
5. Gutters and downspouts
6. Roof surface
7. Exterior doors
8. Exterior door hardware
9. Windows and glass
10. Interior partitions
11. Ceilings
12. Interior doors
13. Interior door hardware
14. Flooring
15. Bathroom fixtures
16. Plumbing other than fixtures
17. Heating system
18. Cooling system
19. Air-handling system
20. Steam-water system
21. Electric circuitry
22. Lighting fixtures
23. Insulation
24. Other ____________
25. Other ____________
26. Other ____________

A. Data Per Type of Cost.

Is there any difficulty obtaining reliable estimates for the four types of life cycle costs (custodial, annual, cyclical and operating)? Please indicate degree of difficulty by placing the category number in the appropriate column.

	Great Difficulty						Moderate Difficulty					
	17	18	19	20	21	22	17	18	19	20	21	22
Custodial	1	1	1	1	0	0	0	0	0	0	1	[illegible]
Annual	2	2	2	1	1	1	0	0	0	1	1	1
Cyclical	2	2	2	1	0	0	1	1	1	2	2	2
Operating (HVAC)	3	3	3	3	0	0	2	2	1	1	1	1

Comments: ____

B. Category Potential.

Please indicate which of the categories have the greatest and least potential for cost savings. Place the number on the appropriate line. If you believe a category has greatest or least potential for cost savings <u>only</u> for certain facility types or utilizations, please indicate this limitation in parentheses.

Great potential ____________________

Least potential ____________________

<u>List of LCC Estimate Sources</u>

1. Facility Engineer
2. Trade association
3. Manufacturer's data
4. Professional society
5. Government research
6. University research
7. Private research
8. Government publications
9. Information from architects/engineers
10. Other ____________
11. Other ____________

C. From the preceding list of cost estimating sources, indicate how often you use each source in making LCC estimates by placing the source's number on the appropriate line.

	1	2	3	4	5	6	7	8	9
Extensively used	48%	17	69	6	19	0	17	10	33
Moderately used	16	30	23	28	19	14	22	30	33
Only used a little	32	30	4	11	29	24	39	50	28
Not used at all	4	22	4	56	33	62	22	10	6

Comments: ____

____

____

____

D. Do you feel that any of the sources of cyclical and annual maintenance information you use have the potential to provide a CE-wide source of cost data for a particular category? Yes 19% No 81%

If yes, name the source and the category. ____________________

____

____

E. For each of the LCC estimate sources, indicate the credibility and/or applicability of each source by placing the source letter on the appropriate line below.

Very credible____________________

Credible____________________

Not credible____________________

Unknown credibility____________________

Comments:____________________

F. In addition to developing a data collection scheme that will fit the districts' LCC needs, CERL must determine which categories to give priority for collecting LCC data. One means of establishing priorities may be to base priority on current maintenance expenditures. Please indicate below which five categories (refer to list of categories) cost the Army the most money to maintain.

APPENDIX B

SUMMARY OF THE LIFE-CYCLE COST DATABASE WORKSHOP
23-24 JULY 1979

Attendees

The LCC Database Workshop was held 23-24 July 1979 at CERL; Table B1 lists the attendees, who included:

1. Personnel from the private sector who provided current experience in LCC analysis and state-of-the-art concepts in LCC database development.

2. A representative from the Facilities Engineering Support Agency who provided information on IFS and its current and future capabilities.

3. A Veterans Administration representative who provided a view of the problem with different emphasis than the Army's.

4. Representatives from the Districts, Divisions, and installations who provided detailed information about their LCC approaches and available data.

The workshop accomplished its objective of providing guidance for future R&D needed to design/develop the database.

Problem Statement

There are requirements that economic analyses be performed during the MCA process. At the programming phase, justification of decisions such as renovation vs. new construction should normally have some economic basis. At concept design, decisions such as brick walls vs. concrete panels should have an economic basis. In final design work, decisions such as vinyl asbestos tile vs. sheet vinyl floor covering requires an economic basis. In each case, the economic analysis incorporates LCC considerations.

LCC analyses are required by Congress and are necessary to insure that Army facilities are designed economically.

LCC analyses require valid data for which uncertainties (variation) are known.

Conclusions and Observations

The following conclusions have been made on the basis of information gained during the workshop.

A comprehensive database for all types of building components and subcomponents would be too expensive and is not needed.

A computerized database is not needed.

At least two databases are needed:

1. A database with a gross level of detail for programming/justificaton purposes. Data would be given for different facility categories and types of construction within categories. This database would be used by installation and OCE personnel.

2. A very detailed database for use by District and installation personnel in final design.

A third database having a level of detail between that of the two databases listed above may also be required by District and installation personnel during concept design.

Detailed databases should be designed and developed primarily for (1) those components requiring large amounts of Army M&R dollars which may be reduced through design, and (2) components which are high-quantity or damage-propagating. Selection of these high-cost items can best be achieved by using data from IFS (and installation records) and the 5-year MCA program. IFS installation tapes with at least one year's valid data can be used to determine those components with high M&R costs for each major facility category. (Check with the installation to verify the costs, since installations may vary somewhat in costing procedures, or some unique occurrence may have inflated the M&R costs.) Through LCC analyses, these high-cost facilities can be compared with planned future construction to select facility types with high potential for M&R savings. A constraint on this procedure is that some high-cost components may not have cost reduction potential through LCC analysis (e.g., plumbing).

MACOMs and installations (through OCE) can use data from IFS for program justification.

The detailed component/subcomponent level database may be obtainable from (1) a survey of FE staffs about their experience with various components/subcomponents, and (2) use of maintenance standards (Army, Navy, Postal Service, GSA, etc.). The questionnaire can also be used to evaluate climatic/geographic differences among installations for components M&R.

The database should have some logical accounting system (such as UNIFORMAT) for building components. The IFS classification system should also be considered for use with the database when this classification is devised.

Some building components/subcomponents interact; the database structure should contain a cross-index system of such interactions.

Labor costs should be expressed in manhours, rather than dollars, to avoid the inflation problem and to avoid varying regional labor rates.

One way of providing benefit cost data to justify the database is to conduct an LCC analysis of a sample of existing CE designs for which no LCC analyses were performed previously. The high-cost components would be LCC analyzed, and the LCC for several alternates compared. This would show what savings could have been made if an LCC analysis had been performed during the original design. Several project cost ranges and design agencies should be sampled. Potential savings can then be estimated by projecting the sample results to the MCA program.

Table B1

Workshop Attendees

'tkinson, J.	Southwest Division	Dallas, TX
Fleming, H.	Veterans Administration	Washington, DC
Gagliano, J.	Fac. Engrg. Support Agency (FESA)	Fort Lee, VA
Grulich, R.	Savannah District	Savannah, GA
Haviland, D.	Rensselaer Poly. Inst.	Troy, NY
Kirk, S.	Smith, Hinchman & Grylls	Washington, DC
Kubo, K.	Norfolk District	Norfolk, VA
McGee, C.	Master Planning Branch	Fort Bragg, NC
Motichko, M.	Engrg. Resources Division	Fort Sill, OK
Murphree, L.	University of Illinois	Urbana, IL
Schindler, L.	OCE, DAEN-MPE-T	Wash DC
Smith, H.	Engrg. Plans Branch	Fort Benning, GA
Wright, A.	Engrg. Resources Division	Fort Campbell, KY
Lotz, E.	CERL-FS	Champaign, IL
Neathammer, R.	CERL-FS	Champaign, IL

APPENDIX C

PROBLEMS IN COLLECTING AND USING DATA FROM ARMY INSTALLATIONS

The first problem with M&R data at Army installations is that it represents M&R performed rather than M&R needed. Thus, if $100 were spent on M&R for a building's floors, it might well be that $1000 should have been expended. Emphasis varies among installations because of existing building conditions, geographical factors, and command/FE philosophies. Allocation of M&R dollars is thus quite arbitrary and may have little to do with the buildings' actual M&R requirements. To use such cost data, one must adapt the attitude that this is the best data available and that it represents what is being done and probably will continue to be done. Furthermore, it is Army data and represents Army facility use. The use of private-sector data (if it were available) would require development of usage conversion factors.

There is a problem with motivating the craftsmen to accurately record job charges. Most of these workers are not paperwork-oriented, and errors do occur; in addition there must be some apportionment of hours for small jobs.

Contract data is not input to the IFS now, but there are plans to do so in the future. However, there are several difficulties in doing this. The FE staff does not have manpower available to enter the data. Requiring the contractor to do so would increase the recordkeeping and hence the M&R contract price. Allocation of costs to building components will be arbitrary; for example, to repair a floor and adjoining wall requires entering costs for two building components (floor, structure). Contractors do not normally keep such detailed cost data. On general maintenance contracts, the FE representative and contractor walk through a building and note what maintenance should be done. In a given building, the contractor may work on several building components. No detailed cost record is kept; only the inspectors' records show what work has been done.

Sometimes the estimators do not break a job into sufficiently detailed tasks to allow cost accruals to individual buildings or building components. For example, changing filters and oiling motors on heating systems in 50 similar buildings may be considered as one task and charged to one building.

The K9000 account is a major problem in that as much as 8 percent of charges made against building types in the Red Book are not assignable to individual buildings. The K9000 account is used to distribute costs of labor chargeable to more than one detailed account; e.g., costs of awards, interns, some benefits; acquisition, maintenance, and repair of hand tools and personnel safety equipment; and some equipment rental. These costs cannot be entered into the IFS on a building-by-building basis, so the IFS data will not reflect "cost of doing business," but only direct charges to the building.

FE organizations are understaffed. There is little they can do either in collecting M&R data or in assisting others to do so.

APPENDIX D

FY79 RED BOOK DATA FOR FORT SILL

ARMY MANAGEMENT STRUCTURE CODES

TRAINING AND DOCTRINE COMMAND

FT. RUCKER, AL

ACTIVITY CODE	ACTIVITY TITLE	UNIT OF MEASURE	BASE UNIT QUANTITY	TOTAL COSTS	UNIT COSTS
	ACTIVE FACILITIES	K SQ FT	8,205	$ 22,585,944	$ 2,752.7
.J0000	OPERATION OF UTILITIES	POP SERV	20,979	5,566,68[illegible]	265.35
.J1000	WATER SERVICE	K GAL	817,796	106,650	.13
.J1100	PURCHASED WATER	K GAL	2,893	4,314	1.49
.J1200	FILTERED WATER	K GAL	---	---	---
.J1300	UNFILTERED WATER	K GAL	814,903	102,336	.13
.J2000	SEWAGE SERVICES	K GAL	523,495	101,798	.19
.J2100	PURCHASED SEWAGE DISPOSAL	K GAL	1,503	1,861	1.24
.J2200	TREATED DOMESTIC SEWAGE	K GAL	521,992	99,937	.19
.J2210	PRIMARY PLANT	K GAL	---	---	---
.J2220	SECONDARY PLANT	K GAL	521,992	99,937	.19
.J2230	ADVANCED WASTEWATER PLANT	K GAL	---	---	---
.J2300	INDUSTRIAL WASTE TREATMENT FACILITIES	K GAL	---	---	---
.J2400	UNTREATED INDUST. WASTES AND/OR COOLING WATER	K GAL	---	---	---
.J3000	ELECTRIC SERVICE	MWH	98,545	3,149,216	31.96
.J3100	PURCHASED ELECTRIC ENERGY	MWH	98,545	3,149,216	31.96
.J3200	ELECTRIC GENERATING PLANTS OPERATION	MWH	---	---	---
.J4100	BOILER PLTS, HI PRESS OVER 3.5 M BTU-HR CAP	M BTU	323,565	1,073,139	3.32
.J4110	GAS FIRED	M BTU	313,451	1,025,524	3.27
.J4120	OIL FIRED	M BTU	10,114	47,615	4.71
.J4130	COAL FIRED	M BTU	---	---	---
.J4200	HEATING PLTS, OVER 3.5 M BTU-HR CAP	M BTU	7,917	37,55[illegible]	4.74
.J4210	GAS FIRED	M BTU	---	---	---
.J4220	OIL FIRED	M BTU	7,917	37,55[illegible]	4.74
.J4230	COAL FIRED	M BTU	---	---	---
.J4300	HEATING PLTS .750 - 3.5 M BTU-HR CAP	M BTU	54,250	138,336	2.55
.J4310	GAS FIRED	M BTU	34,775	72,618	2.09
.J4320	OIL FIRED	M BTU	19,475	65,718	3.37
.J4330	COAL FIRED	M BTU	---	---	---
.J4400	HEATING PLTS UNDER .750 M BTU-HR CAP	M BTU	388,175	957,839	2.47
.J4410	GAS FIRED	M BTU	331,625	783,5[illegible]7	2.36
.J4420	OIL FIRED	M BTU	56,550	174,332	3.[illegible]
.J4430	COAL FIRED	M BTU	---	---	---
.J4500	PURCHASED STEAM & HOT WATER	M BTU	---	---	---
.J5000	AIR CONDITIONING & COLD STORAGE	-	---	---	---
.J5100	AIR CONDITIONING PLTS (OVER 100 TON CAP)	TON CAP	2,347	---	---
.J5200	AIR CONDITIONING PLTS (26 - 100 TON CAP)	TON CAP	3,349	---	---
.J5300	AIR CONDITIONING PLTS (UNDER 26 TON CAP)	TON CAP	9,308	---	---
.J5400	COLD STORAGE PLANTS (INCL ICE MFG)	HP CAP	45	---	---
.J7999	BASE CLOSURES/RIF ACTIONS	-	---	---	---
.J8000	UTILITIES OPERATION (INACTIVE)	-	---	---	---
.J9000	OTHER UTILITIES OPERATION	-	---	2,172	---
.K0000	MAINTENANCE OF REAL PROPERTY	K SQ FT	8,205	9,[illegible]	[illegible]
.K1000	UTILITIES SYSTEMS	-	---	2,12[illegible]	---
.K1100	WATER SYSTEMS	-	---	255,[illegible]	---
.K1110	TREATMENT AND FILTRATION	-	---	---	---
.K1111	PLANTS	K GAL-DAY	---	---	---
.K1112	SOURCE	K GAL-DAY	---	---	---
.K1120	WELLS	K GAL-DAY	5,5[illegible]	[illegible]	[illegible]
.K1130	DISTRIBUTION SYSTEMS	-	---	195,[illegible]	---
.K1131	MAINS AND LATERALS	LIN FT	679,051	58,[illegible]	[illegible]
.K1132	PUMPING STATIONS	K GAL-DAY	6,912	1,[illegible]	.2[illegible]
.K1133	STORAGE	K GAL-CAP	2,348	137,1[illegible]	[illegible]

99AR $ 3,954,125

ARMY MANAGEMENT STRUCTURE CODES

TRAINING AND DOCTRINE COMMAND FT. SILL, OK				TRAINING AND DOCTRINE COMMAND FT. LEONARD WOOD, MO		
BASE UNIT QUANTITY	TOTAL COSTS	UNIT COSTS	ACTIVITY CODE	BASE UNIT QUANTITY	TOTAL COSTS	UNIT COSTS
13,721	$ 28,329,282	$ 2,064.67		12,540	$ 22,811,765	$ 1,819.12
30,385	6,137,629	202.00	.J0000	24,664	7,920,760	325.77
1,084,982	236,801	.22	.J1000	1,399,584	173,190	.12
1,078,008	223,113	.21	.J1100	5,294	5,021	.95
6,273	11,323	1.81	.J1200	1,290,720	161,662	.13
701	2,365	3.37	.J1300	103,570	6,507	.06
776,372	312,160	.40	.J2000	959,703	173,090	.18
77,887	13,099	.18	.J2100	14,025	3,484	.25
698,485	298,961	.43	.J2200	945,678	169,606	.18
---	---	---	.J2210	---	---	---
5,125	9,513	1.86	.J2220	945,678	169,606	.18
693,360	288,948	.42	.J2230	---	---	---
---	---	---	.J2300	---	---	---
---	---	---	.J2400	---	---	---
118,804	2,285,246	19.24	.J3000	116,395	2,739,202	23.53
118,804	2,285,246	19.24	.J3100	116,395	2,739,202	23.53
---	---	---	.J3200	---	---	---
59,327	210,800	3.55	.J4100	573,287	1,989,698	3.47
59,327	198,283	3.34	.J4110	12,979	28,247	2.18
---	12,517	---	.J4120	560,308	1,961,451	3.50
---	---	---	.J4130	---	---	---
301,928	608,682	2.02	.J4200	29,384	92,480	3.15
301,928	608,682	2.02	.J4210	4,267	11,523	2.70
---	---	---	.J4220	25,117	80,957	3.22
---	---	---	.J4230	---	---	---
361,720	863,564	2.39	.J4300	69,479	201,240	2.90
361,720	858,810	2.37	.J4310	21,277	44,662	2.10
---	4,754	---	.J4320	48,202	156,578	3.25
---	---	---	.J4330	---	---	---
747,784	1,559,749	2.09	.J4400	828,825	2,520,199	3.04
747,784	1,494,966	2.00	.J4410	300,264	933,385	3.11
---	64,783	---	.J4420	528,561	1,586,814	3.00
---	---	---	.J4430	---	---	---
---	---	---	.J4500	---	---	---
---	34,979	---	.J5000	---	23,452	---
8,953	19,463	2.17	.J5100	7,847	17,660	2.25
3,523	---	---	.J5200	1,795	---	---
6,491	---	---	.J5300	6,920	---	---
300	15,516	51.72	.J5400	330	5,792	17.55
---	---	---	.J7999	---	---	---
---	---	---	.J8000	---	---	---
---	25,648	---	.J9000	---	[illegible]	---
13,721	15,550,143	1,133.31	.K0000	12,540	10,907,565	869.8
---	5,430,467	---	.K1000	---	1,785,230	---
---	272,710	---	.K1100	---	213,758	---
---	5,286	---	.K1110	---	92,352	---
95	5,286	38.66	.K1111	6,000	48,383	8.06
---	---	---	.K1112	14,900	7,969	.53
---	---	---	.K1120	3,166	84	.05
---	269,424	---	.K1130	---	118,342	---
727,024	256,986	.35	.K1131	1,190,116	55,859	.05
18,981	5,443	.29	.K1132	11,938	62,443	5.23
2,750	6,995	2.54	.K1133	5,500	---	---

BMAR $ 11,275,000

BMAR $ 13,031,000

ARMY MANAGEMENT STRUCTURE CODES

TRAINING AND DOCTRINE COMMAND

FT. RUCKER, AL

ACTIVITY CODE	ACTIVITY TITLE	UNIT OF MEASURE	BASE UNIT QUANTITY	TOTAL COSTS	UNIT COSTS
.K1200	SEWAGE SYSTEMS	-	---	$ 409,840	$ ---
.K1210	TREATMENT PLANTS	-	---	142,082	---
.K1211	PRIMARY PLANT	K GAL-DAY	---	---	---
.K1212	SECONDARY PLANT	K GAL-DAY	2,050	142,082	69.3[illegible]
.K1213	ADVANCED WASTEWATER PLANT	K GAL-DAY	---	---	---
.K1214	INDUSTRIAL WASTE TREATMENT FACILITIES	K GAL-DAY	---	---	---
.K1220	SEWAGE COLLECTION SYSTEMS	-	---	267,758	---
.K1221	SANITARY MAINS & LATERALS	LIN FT	596,055	263,069	.44
.K1222	SANITARY PUMPING PLANTS	K GAL-DAY	7,560	4,689	.62
.K1223	INDUSTRIAL WASTE MAINS & LATERALS	LIN FT	---	---	---
.K1224	INDUSTRIAL WASTE PUMPING PLANTS	K GAL-DAY	---	---	---
.K1300	ELECTRIC SYSTEMS	-	---	127,179	---
.K1310	ELECTRIC GENERATING PLANTS	KVA CAP	---	---	---
.K1321	ELECTRIC DISTRIBUTION SYSTEMS OVERHEAD	LIN FT	1,287,683	37,973	[illegible]
.K1322	ELECTRONIC DISTRIBUTION SYSTEMS UNDERGROUND	LIN FT	892,101	4,155	---
.K1330	ELECTRIC DISTRIBUTION SYSTEMS TRANSFORMERS	KVA CAP	70,792	16,867	.24
.K1340	EXTERIOR LIGHTING	LIGHTS	2,354	62,784	26.67
.K1350	SUBSTATIONS & SWITCHING STATIONS	NO. PLTS	4	5,370	1,342.5[illegible]
.K1410	BOILER PLTS, HI PRESS, OVER 3.5 M BTU-HR CAP	M BTU	154	95,596	620.75
.K1411	GAS FIRED	M BTU	143	94,416	660.25
.K1412	OIL FIRED	M BTU	11	1,180	107.27
.K1413	COAL FIRED	M BTU	---	---	---
.K1420	HEATING PLTS, OVER 3.5 M BTU-HR CAP	M BTU	16	2,162	135.[illegible]
.K1421	GAS FIRED	M BTU	5	---	---
.K1422	OIL FIRED	M BTU	11	2,162	196.55
.K1423	COAL FIRED	M BTU	---	---	---
.K1430	HEATING PLTS, .750 - 3.5 M BTU-HR CAP	M BTU	112	84,506	754.52
.K1431	GAS FIRED	M BTU	76	57,311	754.[illegible]
.K1432	OIL FIRED	M BTU	36	27,195	755.42
.K1433	COAL FIRED	M BTU	---	---	---
.K1440	HEATING PLTS UNDER .750 M BTU-HR CAP	M BTU	234	148,343	633.94
.K1441	GAS FIRED	M BTU	157	93,267	594.[illegible]
.K1442	OIL FIRED	M BTU	77	55,076	715.27
.K1443	COAL FIRED	M BTU	---	---	---
.K1451	STEAM AND HOT WATER DISTRIBUTION SYSTEMS	LIN FT	43,512	72,258	1.66
.K1452	GAS DISTRIBUTION SYSTEMS	LIN FT	219,673	18,456	[illegible]
.K1500	AIR CONDITIONING AND REFRIGERATION	-	---	686,7[illegible]	---
.K1510	AIR CONDITIONING PLTS (OVER 100 TON CAP)	TON CAP	2,347	117,11[illegible]	[illegible]
.K1520	AIR CONDITIONING PLTS (26 - 100 TON CAP)	TON CAP	3,389	235,172	69.39
.K1530	AIR CONDITIONING (5 - 25 TON)	TON CAP	3,919	215,869	55.[illegible]
.K1540	AIR CONDITIONING (UNDER 5 TON)	TON CAP	5,349	69,118	12.93
.K1550	REFRIGERATION (5 - 25 TON)	HP CAP	132	4,248	32.1[illegible]
.K1560	REFRIGERATION (UNDER 5 TON)	HP CAP	3,029	39,3[illegible]1	12.9[illegible]
.K1570	COLD STORAGE PLTS (INCL ICE MFG)	HP CAP	85	6,142	72.2[illegible]
.K1900	OTHER UTILITIES	-	---	218,293	---
.K1910	MECH VENT & EVAP COOLING	UNITS	3,867	45	[illegible]
.K1940	LIQUID STORAGE FACILITIES	FACIL	23	5,635	245.[illegible]
.K1952	INTRUSION DETECTION SYSTEMS	SYSTEMS	50	25,423	5[illegible]
.K1999	ALL OTHER	-	---	187,19[illegible]	---
.K2000	BUILDINGS	K SQ FT	8,205	3,89[illegible],476	4[illegible]
.K2100	TRAINING	K SQ FT	781	177,0[illegible]	22[illegible].7[illegible]
.K2200	MAINTENANCE & PRODUCTION	K SQ FT	848	237,1[illegible]	279.65
.K2300	RESEARCH, DEVELOPMENT & TEST	K SQ FT	51	16,2[illegible]	31[illegible].65
.K2410	AMMUNITION STORAGE	K SQ FT	14	2,082	148.71
.K2420	OTHER COVERED STORAGE	K SQ FT	636	47,843	7[illegible].3[illegible]
.K2500	HOSPITAL & MEDICAL	K SQ FT	311	193,276	[illegible]
.K2600	ADMINISTRATION	K SQ FT	374	182,926	489.11
.K2700	BACHELOR HOUSING	K SQ FT	2,088	1,756,217	841.1[illegible]
.K2800	COMMUNITY	K SQ FT	666	211,385	317.39
.K2910	FAMILY HOUSING	K SQ FT	2,086	993,241	476.15
.K2920	OPERATIONAL BUILDINGS	K SQ FT	215	28,3[illegible]3	131.64
.K2930	UTILITY PLANT BUILDINGS	K SQ FT	61	31,668	5[illegible]2.75
.K2990	OTHER BUILDINGS	K SQ FT	74	14,059	189.99
.K3000	GROUNDS MAINTENANCE	ACRE	62,157	833,038	13.4[illegible]
.K3100	IMPROVED GROUNDS	ACRE	16,376	766,444	46.8[illegible]
.K3210	WILDLIFE MANAGEMENT	ACRE	(47,000)	27,775	.59
.K3290	OTHER THAN IMPROVED GROUNDS	ACRE	45,791	38,819	.85
.K4000	RAILROAD MAINTENANCE (ACTIVE)	K LIN FT	35	80,027	2,286.49
.K5000	SURFACED AREAS MAINTENANCE (LESS K5800)	K SQ YDS	6,817	1,861,475	273.[illegible]
.K5110	ROADS - CONCRETE AND BITUMINOUS	K SQ YDS	1,427	792,71[illegible]	555.5[illegible]
.K5120	ROADS - OTHER MISC	K SQ YDS	881	34,834	39.54
.K5210	AIRFIELD PAVEMENTS - CONCRETE & BITUMINOUS	K SQ YDS	3,050	942,028	3[illegible]8.86
.K5220	AIRFIELD PAVEMENTS - OTHER MISC	K SQ YDS	311	19,9[illegible]6	64.[illegible]
.K5310	PARKING, WALKS, ETC- CONCRETE & BITUMINOUS	K SQ YDS	1,039	61,646	59.33
.K5320	PARKING, WALKS, ETC - OTHER MISC	K SQ YDS	109	10,347	94.93

ARMY MANAGEMENT STRUCTURE CODES

TRAINING AND DOCTRINE COMMAND FT. SILL, OK				TRAINING AND DOCTRINE COMMAND FT. LEONARD WOOD, MO		
BASE UNIT QUANTITY	TOTAL COSTS	UNIT COSTS	ACTIVITY CODE	BASE UNIT QUANTITY	TOTAL COSTS	UNIT COSTS
---	$ 1,114,239	$ ---	.K1200	---	$ 81,868	$ ---
---	143,786	---	.K1210	---	34,106	---
---	---	---	.K1211	---	---	---
52	78,740	1,514.23	.K1212	5,500	34,106	6.20
4,200	65,046	15.49	.K1213	---	---	---
---	---	---	.K1218	---	---	---
---	970,453	---	.K1220	---	47,762	---
566,638	927,984	1.64	.K1221	861,191	36,408	.04
2,117	42,469	20.06	.K1222	13,104	11,354	.87
---	---	---	.K1223	---	---	---
---	---	---	.K1224	---	---	---
---	403,922	---	.K1300	---	469,533	---
---	---	---	.K1310	---	---	---
1,112,929	69,500	.06	.K1321	1,864,386	206,686	.11
332,378	123,108	.37	.K1322	289,000	739	---
76,770	85,259	1.11	.K1330	86,636	47,141	.54
3,566	124,175	34.82	.K1340	5,387	213,567	39.64
3	1,880	626.67	.K1350	3	1,400	466.67
38	21,454	564.58	.K1410	379	132,677	350.07
38	21,108	555.47	.K1411	34	3,458	101.71
---	346	---	.K1412	345	129,219	374.55
---	---	---	.K1413	---	---	---
358	334,512	934.39	.K1420	54	10,794	199.89
358	334,458	934.24	.K1421	22	1,743	79.23
---	54	---	.K1422	32	9,051	282.84
---	---	---	.K1423	---	---	---
519	376,386	725.21	.K1430	113	44,957	397.85
519	376,386	725.21	.K1431	43	8,665	201.51
---	---	---	.K1432	70	36,292	518.46
---	---	---	.K1433	---	---	---
889	739,467	831.80	.K1440	265	151,147	570.37
889	739,467	831.80	.K1441	53	9,802	184.94
---	---	---	.K1442	212	141,345	666.72
---	---	---	.K1443	---	---	---
56,000	154,505	2.76	.K1451	80,329	37,548	.47
526,945	109,444	.21	.K1452	108,105	4,779	.04
---	1,635,225	---	.K1500	---	383,058	---
8,953	461,540	51.55	.K1510	7,847	35,289	4.50
3,523	379,678	107.77	.K1520	1,795	68,506	38.16
2,379	481,279	202.30	.K1530	2,235	162,256	72.60
4,112	117,430	28.56	.K1540	4,685	3,800	.81
769	35,442	46.09	.K1550	245	698	2.85
1,513	151,171	99.91	.K1560	116	10,975	94.61
300	8,685	28.95	.K1570	330	101,534	307.68
---	268,623	---	.K1900	---	258,111	---
6,487	113,606	17.51	.K1910	---	---	---
97	2,154	22.21	.K1940	52	101,050	1,943.27
70	29,388	419.83	.K1952	123	20,111	163.50
---	123,475	---	.K1988	---	136,950	---
13,721	6,458,397	470.69	.K2000	12,540	7,224,639	576.13
1,734	972,534	560.86	.K2100	1,146	383,600	334.73
1,181	574,501	486.52	.K2200	532	579,036	1,088.41
10	5,097	509.70	.K2300	---	---	---
83	42,935	517.29	.K2410	50	1,023	20.46
900	202,122	224.58	.K2420	539	103,784	192.55
283	264,920	936.11	.K2500	457	270,657	592.25
782	212,431	271.65	.K2600	357	168,814	472.87
4,709	2,331,520	495.12	.K2700	4,153	1,580,959	380.68
1,197	403,567	340.31	.K2800	1,162	298,399	256.80
2,517	1,361,110	540.77	.K2910	3,616	3,638,109	1,006.11
156	58,358	374.09	.K2920	423	45,617	107.84
89	17,547	197.61	.K2930	105	154,641	1,472.77
90	11,599	128.88	.K2990	---	---	---
150,002	1,286,112	8.57	.K3000	72,208	919,818	12.74
24,796	1,044,408	42.12	.K3100	7,591	829,492	109.27
124,101	160,940	1.30	.K3210	250	39,755	159.02
125,206	80,764	.65	.K3290	64,617	50,571	.78
59	3,866	65.53	.K4000	169	85,951	508.59
12,568	1,955,005	155.55	.K5000	7,516	608,322	80.94
2,536	899,716	354.78	.K5110	4,058	425,149	104.78
4,871	58,258	11.96	.K5120	977	103,697	106.14
384	5,093	13.26	.K5210	148	130	.88
40	27,846	696.15	.K5220	2	---	---
4,228	942,717	222.97	.K5310	2,291	62,017	27.07
509	21,379	41.99	.K5320	40	17,289	432.23

ARMY MANAGEMENT STRUCTURE CODES

TRAINING AND DOCTRINE COMMAND

FT. RUCKER, AL

ACTIVITY CODE	ACTIVITY TITLE	UNIT OF MEASURE	BASE UNIT QUANTITY	TOTAL COSTS	UNIT COSTS
.K5900	BRIDGES, VEHICULAR RAILROAD & FOOT	LEN FT	5,808	$ 95,067	$ 16.37
.K6000	MISCELLANEOUS MAINTENANCE	-	---	210,847	---
.K6100	WATER FRONT FACILITIES & WATERWAY	-	---	554	---
.K6200	M, R & A SHOP - MACH SHOP	-	---	33,077	---
.K6300	BLDG RELATED FACILITIES	-	---	177,216	---
.K6400	NATIONAL HISTORIC PRESERVATION PROGRAM	FACIL	---	---	---
.K7999	BASE CLOSURES/RIF ACTIONS	-	---	---	---
K8000	MAINTENANCE & REPAIR (INACTIVE)	K SQ FT	147	---	---
.K9000	FACIL ENGR SHOP SUPENSE ACCTS	-	---	10,987	---
.L0000	MINOR CONSTRUCTION	& OF K	19	1,701,646	---
.L1000	ALTERATION & MINOR CONSTRUCTION	-	---	1,701,646	---
.L7999	BASE CLOSURES/RIF ACTIONS	-	---	---	---
.L8000	ALTERATIONS & MINOR CONSTRUCTION (INACTIVE)	-	---	---	---
.M0000	OTHER ENGINEERING SUPPORT	-	---	6,215,461	---
.M1000	FIRE PREVENTION & PROTECTION	K SQ FT	8,352	3,196,859	382.53
.M2000	REFUSE HANDLING	K CU YDS	170	278,146	1,636.15
.M2100	COLLECTION	K CU YDS	170	241,194	1,418.79
.M2200	DISPOSAL	K CU YDS	171	36,952	216.09
.M2210	SANITARY FILL	K CU YDS	171	36,240	211.93
.M2220	INCINERATION	K CU YDS	---	---	---
.M2230	RESOURCE RECOVERY-RECYCLING	K CU YDS	---	---	---
.M2240	SOURCE SEPARATION OF PAPER	K CU YDS	---	---	---
.M2250	OTHER	K CU YDS	---	712	---
.M3000	PEST CONTROL SERVICES	-	---	93,711	---
.M3100	BUILDINGS	K SQ FT	8,352	76,695	9.18
.M3200	GROUNDS	ACRES	62,167	17,016	.27
.M4000	CUSTODIAL SERVICES	K SQ FT	1,538	624,023	405.74
.M4100	CONTRACT	K SQ FT	1,384	510,591	368.92
.M4200	IN-HOUSE	K SQ FT	154	113,432	736.57
.M5000	SNOW/SAND REMOVAL & ICE ALLEVIATION	-	---	---	---
.M6000	MGMT & ENGINEERING(ACTIVE)(INCL MASTER PLANNING)	% TOTAL	5	1,213,937	---
.M6100	MGMT & ENGINEERING (LESS MASTER PLANNING)	-	---	1,043,644	---
.M6200	MASTER PLANNING	-	---	96,062	---
.M6300	ENVIRONMENTAL PROGRAM MGMT	-	---	74,231	---
.M7999	BASE CLOSURES/RIF ACTIONS	-	---	---	---
.M8000	ENGINEERING SUPPORT (INACTIVE)	-	---	---	---
.M8100	MGMT & ENGINEERING (INACTIVE)	-	---	---	---
.M8200	OTHER ENGINEERING ACTIVITIES (INACTIVE)	-	---	---	---
.M8300	ENVIRONMENTAL PROGRAM MGMT (INACTIVE)	-	---	---	---
.M9000	MISCELLANEOUS ENGINEER ACTIVITIES	-	---	810,785	---
.M9110	RENTS, INTIAL ALTERATIONS & RESTORATION	-	---	250,319	---
.M9120	LAND PAYMENTS	-	---	---	---
.M9130	DEFICIENCY JUDGEMENT	-	---	---	---
.M9200	INSTALLATION OF INTRUSION DETECTION SYSTEMS	NO. INST.	6	5,882	980.33
.M9300	FAMILY HOUSING HOUSEHOLD - EQUIPMENT MAINT	NO UNITS	3,032	---	---
		MAN HRS	1,159	16,162	13.94
.M9410	SPECIAL MAINTENANCE ACTIVITIES NON-REIMB	-	---	135,441	---
.M9420	SPECIAL MAINTENANCE ACTIVITIES REIMB	-	---	28,469	---
.M9500	PACKING & CRATING	-	---	40,518	---
.M9610	FACILITIES ENGINEERING SUPPLY OPERATIONS	-	---	214,876	---
.M9620	INVENTORY SUSPENSE ACCOUNTS	-	---	---	---
.M9700	PURCHASED FACILITIES ENGINEERING SERVICES	-	---	---	---
.M9800	MES EQUIP ACQ AND OPER & MAINTENANCE	-	---	99,996	---
.M9810	MES EQUIPMENT ACQUISTION	-	---	---	---
.M9820	MES EQUIPMENT OPER & MAINTENANCE (NET)	-	52	99,996	---
.M9821	MES EQUIPMENT OPER & MAINTENANCE (DEBIT)	-	---	531,819	---
.M9822	MES EQUIPMENT OPER & MAINTENANCE (CREDIT)	-	---	431,823	---
.M9900	DEMOLITION OF REAL PROPERTY	K SQ FT	---	19,272	---
.MA000	EQUIPMENT IN PLACE	-	---	---	---

ARMY MANAGEMENT STRUCTURE CODES

TRAINING AND DOCTRINE COMMAND — FT. SILL, OK | TRAINING AND DOCTRINE COMMAND — FT. LEONARD WOOD, MO

BASE UNIT QUANTITY	TOTAL COSTS	UNIT COSTS	ACTIVITY CODE	BASE UNIT QUANTITY	TOTAL COSTS	UNIT COSTS
2,197	$ 9,001	$ 4.10	.K5000	11	$ 670	$ 60.91
---	406,690	---	.K6000	---	270,236	---
---	---	---	.K6100	---	---	---
---	87,003	---	.K6200	---	---	---
---	315,506	---	.K6300	---	270,236	---
45	4,181	92.91	.K6400	---	---	---
---	---	---	.K7999	---	---	---
---	---	---	.K8000	---	---	---
---	595	---	.K9000	---	12,257	---
10	1,512,959	---	.L0000	6	623,554	---
---	1,512,959	---	.L1000	---	623,554	---
---	---	---	.L7999	---	---	---
---	---	---	.LF000	---	---	---
---	5,128,551	---	.M0000	---	3,360,136	---
13,721	894,891	65.22	.M1000	12,540	609,777	48.63
313	493,516	1,576.73	.M2000	300	448,513	1,495.04
313	361,673	1,155.50	.M2100	300	309,422	1,031.41
416	131,843	316.93	.M2200	327	139,091	425.35
359	19,182	53.43	.M2210	327	139,091	425.35
---	141	---	.M2220	---	---	---
1	2,547	2,547.[illegible]	.M2230	---	---	---
8	28,632	3,579.[illegible]	.M2240	---	---	---
48	81,491	1,697.73	.M2250	---	---	---
---	197,[illegible]2	---	.M3000	---	1[illegible]3,993	---
13,721	122,654	8.94	.M3100	12,540	90,426	7.21
150,002	75,2[illegible]8	[illegible]	.M3200	3,611	13,567	3.76
1,447	742,123	5[illegible]2.87	.M4000	838	304,437	363.29
1,447	734,[illegible]	5[illegible]7.33	.M4100	480	208,745	434.89
---	8,[illegible]	---	.M4200	358	95,692	267.3
---	11[illegible],266	---	.M5000	---	110,115	---
6	1,728,[illegible]	---	.M6000	4	950,099	---
---	1,284,[illegible]	---	.M6100	---	866,068	---
---	3[illegible]	---	.M6200	---	31,824	---
---	14[illegible]	---	.M6300	---	52,2[illegible]7	---
---	---	---	.M7000	---	---	---
---	---	---	.M8000	---	---	---
---	---	---	.M8100	---	---	---
---	---	---	.M8200	---	---	---
---	---	---	.M8300	---	---	---
---	957,7[illegible]2	---	.M9000	---	833,172	---
---	234,119	---	.M9110	---	135,197	---
---	---	---	.M9120	---	---	---
---	---	---	.M913C	---	---	---
2	7,326	3,663.00	.M9200	150	16,081	107.21
2,811	---	---	.M9300	4,830	---	---
2,953	39,966	13.53		---	---	---
---	69,746	---	.M9410	---	147,1[illegible]9	---
---	12,432	---	.M9420	---	77,73[illegible]	---
---	8[illegible],88[illegible]	---	.M9500	---	34,5[illegible]	---
---	377,112	---	.M9610	---	189,156	---
---	---	---	.M9620	---	---	---
---	---	---	.M9700	---	---	---
---	91,769-	---	.M9800	---	190,11[illegible]	---
---	21,285	---	.M9810	---	19,563	---
---	333,050-	---	.M9820	60	17[illegible],547	---
---	603,928	---	.M9821	---	477,76[illegible]	---
---	716,962	---	.M9822	---	3[illegible]7,213	---
---	15,173	---	.M9900	---	42,966	---
---	210,717	---	.MA000	---	235	---

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Neathammer, Robert D
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